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the structure of the lungs, the life and structure of which are thereby modified. Each form of dust stimulates a special reaction of its own, while mixed dusts set up a mixed reaction. No evidence is put forward that dusts other than those of silica or silicates are harmful, or that any dust is capable of reducing the toxic influence of any other.

**E.J.V.**  
**Investigations on quartz and asbestos analysis of industrial dusts.** F. SANDOZ and E. W. JORRAN. *Arch. Hyg. & Bacteriol.* 115, 135-51 (1933); abstracted in *Jour. Ind. Hyg. & Toxicol.* 18 [4] 54 (1935).—The separation of various mineral constituents of dusts by the use of liquids having suitable specific gravities is discussed. The standard methods of mineralogical and chemical analysis of dusts are mentioned, with a description of the X-ray examination. Some of the common minerals are shown.

**E.J.V.**  
**Methods of dust control.** J. D. LUTCH. *Trans. Amer. Foundrymen's Assn.* 7 [1] 220-21 (1934).—The point to begin elimination of the dust hazard is at the source. Methods used for controlling the dust hazards originating at different types of sources are described. 1. Discusses the general methods used in dust-suppression problems and the estimation of the hazard, considering that the efficiency of a dust-collection system is best determined by dust counts. Methods used for testing venting equipment and the selection of fans are presented. Dust collectors and respirators, such as balastris, filter-type respirators, and positive-pressure masks, are discussed. Maintenance of equipment is necessary to the successful operation of such equipment and to the efficiency of any installation. A discussion is included.

**E.E.S.**  
**Melting of clay after heating at various temperatures.** R. MONTY. *Ceramic News*, 15, 221-23 (1934); *Chem. Ind.* 1934, 10, 5296; *Brit. Chem. Abstr.* 5, 54 [57] 591 (1935).—Heating at 140° to 300° before molding increases the apparent porosity of the product fired at 900° and decreases the resistance to breaking of a specimen dried at 120°.

**E.E.S.**  
**Monograph for ceramic calculations.** A. A. GORDON. *Monograph*, 3 [3] 374-78 (1933).—The monograph facilitates the chemical analyses and the calculation of the amount of oxides in the fired product and of the raw material required for a given quantity of the latter.

**P.B. & E.S.**  
**Personal management.** J. E. WALTER. *Factory Management & Maintenance*, 94 [12] 5335-44 (1933).—The topics considered are (1) personnel management, (2) selection of employees, (3) personnel maintenance, (4) training and education, (5) medical and health service, (6) safety and accident prevention, and (7) personnel service work. Figures, tables, and photographs are included.

**J.L.G.**  
**Significance of free crystalline silica in the etiology of silicosis and silicatuberculosis.** E. W. JORRAN and H. POWERS. *Med. Wkly.* 10, 545-50 (1935); abstracted in *Jour. Ind. Hyg. & Toxicol.* 18 [8] 120-31 (1935).—The silicosis-dusted rabbits were a period of four years, first 2, then 3, then 6 hr. daily with porcelain dust having 30% free silica and 1 to 2% free silica. After this period the animals

male showed no typical silicosis although there could be seen sharp, pinpoint-sized, superficial nodules and a slight increase of fibrosis. During the dusting, tubercle bacilli were administered intravenously. These grew slowly, and with increasing processes, into a pulmonary tuberculosis while the controls showed no noteworthy disposition to contract tuberculosis. It is concluded that over a 2 to 4 year period of dusting with tubercle bacilli injected, it was possible to produce a tuberculosilicosis, although with the dust alone it was not possible to show silicosis, in spite of the presence of virulent. By dusting with pure quartz (without tubercle bacilli injection and without virulent) for 1 hr. daily for 2 years, typical silicosis nodules were produced.

**E.J.V.**  
**Silicosis analysis in industrial dusts.** F. SANDOZ and E. W. JORRAN. *Zentr. Gewerbel., & Unfallheilk.* 21, 65-69 (1934).—Materials studied were from the Rhine Steel Works, the Thyssen, and the U. S. Steel Co. Tables show in detail the procedure and results, accompanied by ample comment and description of methods involved. If dusty occupations are to be graded on a danger scale over long or short periods, the silicosis percentages and dust analysis must be carefully compared. These new research methods are concerned with the size of grains in dust raised and the accurate preparation of undisturbed acid particles, thus serving the combined purposes of mechanical phase analysis and chemical analysis. Important insight into the structure of different kinds of dust has been gained, and this has been increased by using definite purity tests, e.g., the terral method.

**E.E.**  
**Silicosis: harmful dusts which cause it.** W. R. JORRAN. *Trans. Foundrymen's Assn.* 34, 303-43 (1935); see *Ceramic Abstr.* 14 [2] 94 (1935).

**E.J.V.**  
**Silicosis in the porcelain industry from the standpoint of the physician.** SCHULFARSKY. *Brit. Med. Jour.* 60, 17 [6] 225-30 (1934).—It is pointed out that a silicosis lung rarely occurs by itself, being usually associated with tuberculosis. A description of a silicosis lung is given. 5. outlines the two theories of silicosis, mechanical and chemical, and discusses the chemical aspect of the problem.

**E.J.V.**  
**Training your own instrument men.** ALPHEA G. MOON. *Instrument.* 10 [1] 15-18 (1937).—34, reviews basic considerations, qualifications of candidates, training of instrument men, division of time between various types of repair jobs, supplementary educational work, progress reports, and rating guide to be used in semiannual check-up.

#### BOOKS AND BULLETINS

**Determination and Control of Industrial Dust.** J. J. BLOOMFIELD and J. M. DALLAWALK. U. S. Pub. Health Bull., No. 217, 167 pp. (April, 1935).—This brief but comprehensive work presents "the methods and instruments used in conducting dust studies in industry, the interpretation of results thus obtained, and their practical application to industrial problems, especially those phases relating to control of the dust hazard." Preliminary procedure involves the sanitary and occupational survey of a plant; and emphasis is placed on personal respiratory protection of workers. Between these occurs the dust technique.

## ADDRESSES AND ORIGINAL ARTICLES

### INDUSTRIAL PULMONARY DISEASE DUE TO THE INHALATION OF DUST WITH SPECIAL REFERENCE TO SILICOSIS\*

By E. L. MIDDLETON, M.D. Edin., D.P.H.  
M.M. MEDICAL DIRECTOR OF FACTORIES

THE aim in these lectures is to reach some conclusions regarding the etiology of silicosis from a study of the occupations in which it occurs. In order to save confusion as to the condition to which the term silicosis is applied, the typical form of the disease is briefly described. The spread of the disease over the industries in this country is referred to and some of the occupations are more closely studied. It will be found that in all these occupations in which silicosis occurred there had been exposure to the inhalation of dust of free silica.

Besides the industries in which silicosis occurs, certain occupations are referred to in which the workers are exposed to dust of silicates without free silica, and the changes following such exposure are described. These form a contrast with the characteristics of silicosis and, in general, they conform to the description of a condition which has been called "silicatosis."

#### Silicosis

Silicosis is the most important of that group of diseases which have been termed collectively the pneumoconioses. It is this country it is always the result of prolonged exposure to certain kinds of dust in the course of occupation. The onset of symptoms is marked by dyspnea. Silica at first, noticeable only after prolonged or unusual exertion, it remains the most important symptom and is progressive throughout the course of the disease. In the early stage physical signs are characteristic, but they must be sought for with care. In the first stage the radiograph shows the presence of discrete shadows indicative of nodulation. In the second stage dyspnea and cough become established and greater changes are noted in the physical signs. The radiograph shows the whole of both lung fields occupied by shadows indicative of nodulation, and there is some coalescence to form more or less dense opacities. There is always some degree of impairment of working capacity. The third stage is reached with total incapacity, through increasing severity of symptoms of which dyspnea is the most distressing. The radiograph indicates areas of massive consolidation. Pulmonary tuberculosis may be present in any stage of silicosis. It may alter the symptoms, physical signs, radiological appearances, and the whole course of the disease. It is the most frequent accompaniment of silicosis.

**Post-mortem appearances.**—In fatal cases of uncomplicated silicosis the lungs are generally large, of increased density, and retain their shape on removal from the chest. Fibrillar adhesions are nearly always present and may be extensive and of long standing. On parts of the lung not covered by adhesions the pleura is typically mottled a grey colour and studded over with whitish mammillated nodules, each of which

can be felt above the general surface and to be part of a nodule which extends into the lung.

The cut surface of the lung shows a pattern of pigmentation throughout its extent, but the striking and distinctive feature is the presence of numerous rounded nodules. These are dense, tough, or hard, and the cut surface is grey or black. Each nodule is from 2 to 5 mm. in diameter, but several may be aggregated together to form large composite nodules, or many may be united in a massive fibrosis. In old-standing cases individual nodules may be sharply defined from the surrounding lung tissue, which may show emphysema. The centre of the nodule may have undergone calcareous change. In fatal cases, where exposure to dust has been intense and the course of the disease relatively rapid, the nodules may be so crowded that practically no lung tissue can be seen remaining. This condition is found in some sandblasters and it appears to follow exposure to highly siliceous dust—i.e., dust containing a very high proportion of free silica.

Gardner<sup>1</sup> described the pathological changes of the lungs in 15 cases of so-called "acute" silicosis. There were masses of small nodules embedded in broad sheets of fibrous tissue, a generalized thickeness of the alveolar walls, and slight involvement of the glands.

The distribution of the fibrosis is not always uniform and discrete, but in certain cases it is condensed in large masses, of rounded or oval shape usually about the middle zones, but the masses may be multiple. This form of distribution is met with typically amongst coal-miners and is described by observers in France and Belgium, as well as in this country.<sup>2</sup>

The diagnosis of silicosis is made post mortem on the macroscopic evidence of nodules which are palpable. The fibrous nodules in the essential and characteristic lesion of simple silicosis. Recourse to histological examination is usually necessary for diagnosis only in the presence of complications—namely tuberculosis and malignant disease. The presence of tuberculosis may render the diagnosis very difficult. According to Kettle<sup>3</sup> the differential diagnosis depends on the amount and distribution of the collapse in the tissue reaction; it is a matter of degree and there are no definite standards on which to base an opinion. Folkes and Morrell<sup>4</sup> applied a spectrographic method for the detection of mineral particles in pulmonary tissue, and Irwin<sup>5</sup> has developed a method for the demonstration of silicosis material in histological sections, as an aid to diagnosis, by incineration and treatment with acid.

Clinical and radiological examinations at earlier stages in the progress of the disease can be of immense importance in the diagnosis of complicated cases. Changes in the lymphatic glands usually occur early in the course of silicosis. At first enlarged, they are found in more advanced cases hard and on section dark grey or black, often showing tubercular concentrically arranged systems of nodular fibrosis. The lymphatic glands may show foci of silicosis when tuberculous lesions are not apparent in extensively silicified lungs.

#### Examination of the Dust-cloud

The International Conference on Silicosis held at Johannesburg in 1930<sup>6</sup> adopted the view that in order to produce the pathological condition known

\*The lecture given for 1935 delivered before the Royal College of Physicians, London, on July 1st, 1935. The second lecture will appear in the next issue of THE LANCET.







industrially healthy South Wales coal-miners.<sup>10</sup> The distinction in the degrees of change found between workers in anthracite coal and in bituminous coal agree with those

District.	Number of wage-earners employed in Dec. 14th, 1935.	Number of certificates issued free—	Percentage.	
		Death.	Total Available.	
1.	1,000	100	1,000	10
2.	2,000	200	2,000	10
3.	3,000	300	3,000	10
4.	4,000	400	4,000	10
5.	5,000	500	5,000	10
6.	6,000	600	6,000	10
7.	7,000	700	7,000	10
8.	8,000	800	8,000	10
9.	9,000	900	9,000	10
10.	10,000	1,000	10,000	10
11.	11,000	1,100	11,000	10
12.	12,000	1,200	12,000	10
13.	13,000	1,300	13,000	10
14.	14,000	1,400	14,000	10
15.	15,000	1,500	15,000	10
16.	16,000	1,600	16,000	10
17.	17,000	1,700	17,000	10
18.	18,000	1,800	18,000	10
19.	19,000	1,900	19,000	10
20.	20,000	2,000	20,000	10
21.	21,000	2,100	21,000	10
22.	22,000	2,200	22,000	10
23.	23,000	2,300	23,000	10
24.	24,000	2,400	24,000	10
25.	25,000	2,500	25,000	10
26.	26,000	2,600	26,000	10
27.	27,000	2,700	27,000	10
28.	28,000	2,800	28,000	10
29.	29,000	2,900	29,000	10
30.	30,000	3,000	30,000	10
31.	31,000	3,100	31,000	10
32.	32,000	3,200	32,000	10
33.	33,000	3,300	33,000	10
34.	34,000	3,400	34,000	10
35.	35,000	3,500	35,000	10
36.	36,000	3,600	36,000	10
37.	37,000	3,700	37,000	10
38.	38,000	3,800	38,000	10
39.	39,000	3,900	39,000	10
40.	40,000	4,000	40,000	10
41.	41,000	4,100	41,000	10
42.	42,000	4,200	42,000	10
43.	43,000	4,300	43,000	10
44.	44,000	4,400	44,000	10
45.	45,000	4,500	45,000	10
46.	46,000	4,600	46,000	10
47.	47,000	4,700	47,000	10
48.	48,000	4,800	48,000	10
49.	49,000	4,900	49,000	10
50.	50,000	5,000	50,000	10
51.	51,000	5,100	51,000	10
52.	52,000	5,200	52,000	10
53.	53,000	5,300	53,000	10
54.	54,000	5,400	54,000	10
55.	55,000	5,500	55,000	10
56.	56,000	5,600	56,000	10
57.	57,000	5,700	57,000	10
58.	58,000	5,800	58,000	10
59.	59,000	5,900	59,000	10
60.	60,000	6,000	60,000	10
61.	61,000	6,100	61,000	10
62.	62,000	6,200	62,000	10
63.	63,000	6,300	63,000	10
64.	64,000	6,400	64,000	10
65.	65,000	6,500	65,000	10
66.	66,000	6,600	66,000	10
67.	67,000	6,700	67,000	10
68.	68,000	6,800	68,000	10
69.	69,000	6,900	69,000	10
70.	70,000	7,000		

			ALL-INDIA	
ENGLAND				
Northumberland and Durham	..	43,865	1	..
Cumberland and Westmorland	..	104,544	2	..
..	..	..	..	..
..	..	4,882	..	..
South Yorkshire	..	94,437	4	10
West Yorkshire	..	41,991	3	1
Leicestershire and Cheshire	..	29,607	5	5
North Derbyshire	..	41,213	..	..
Nottingham	..	44,832	1	..
South Derbyshire	..	3,179	..	..
Lincolnshire	..	90,685	1	..
Cannock Chase	..	21,560	1	..

North Staffordshire .. ..	21,343	3	16	6
South Staffordshire and Worcestershire .. ..	4,660	..	3	..
Shropshire .. ..	2,633	..	1	..
Warwickshire .. ..	16,391	..	..	..
Forest of Dean .. ..	5,075	..	2	2

Bristol	..	..	..	522	..	..	..
Donnerstag	..	..	..	5,410	5	17	7
Kent	..	..	..	7,302	2	6	3
<b>Total</b>	<b>..</b>	<b>..</b>	<b>..</b>	<b>531,894</b>	<b>22</b>	<b>66</b>	<b>25</b>
<b>WALLES.</b>							
South Wales and Monmouth	..	..	..	130,552	167	512	198
North Wales	..	..	..	8,876	..	1	..
<b>Total</b>	<b>..</b>	<b>..</b>	<b>..</b>	<b>139,428</b>	<b>167</b>	<b>513</b>	<b>198</b>

SCOTLAND.				
Fife and Clackmannan ..	21,698	..	..	3
Lothian (Mid and East) ..	12,478	..	2	..
Leathkshire .. ..	30,820	..	1	2
Ayrshire .. ..	11,311	..	..	..

Total	..	..	84,338	..	3	237
GRANT BRITAIN	..	..	750,160	169	581	4

The radiograph showed no signs of significant mottling in two bilateral apical areas, in one, and in one mottling in two. In the report of studies made in the Anthracite Region of Pennsylvania by the United States Public Health Service<sup>1</sup> the results of examination of a total number of 2711 workers in 3 anthracite coal-mines are described. Anthraco-silicosis was found in 23 per cent., and the incidence varied with the period of employment, and the concentration and nature of the dust to which they were exposed. Böhm<sup>2</sup> described the results of examination of 3318 rock-drillers working in the Ruhr coal-mines for periods from 5 to 25 years. Of these, 1844 per cent. showed changes of varying degrees of severity, from stage I to stage IV. 167 men took a leave of 2 to 8 years.

From a study of systematic examinations of 9807 stone-workers in the coal-mines of the Ruhr district

**INHIBITION AND INDUCTION OF  
UTERINE BLEEDING BY MEANS OF  
OESTRONE**

By S. ZUCKERMAN, D.Sc. Lond., M.R.C.S. Eng.  
JERD MEMORIAL RESEARCH FELLOW

(From the Department of Human Anatomy, Oxford)

THE increasing clinical importance of oestrogen\* in the treatment of conditions such as amenorrhoea or sterility resulting from uterine hypoplasia makes it necessary that the available data about the physiological actions of oestrogen on the primates uterus should be properly understood. At the present time two apparently conflicting statements are made on this subject: the first, that the continuous injection of the hormone inhibits menstrual bleeding, and the second, that uterine bleeding occurs even in castrated

tomised human beings and monkeys, during the course of prolonged oestrin treatment. The purpose of this paper is to examine the facts bearing on these two points.

Allens's observation that the cessation of injections of oestrin into castrated monkeys is succeeded after a few days by a phase of uterine bleeding constitutes the first definite knowledge of the endocrine control of the primate endometrium. His finding has been repeatedly confirmed, both on monkeys and on human beings, and the bleeding occurred in this way has been justifiably related to that occurring either after removal of the ovaries or after rupture of ovarian follicles. In both cases the bleeding that normally follows these procedures can be delayed or forestalled with oestrogens, but immediately after

The normal histological effects of oestrin on the primate endometrium have also been elucidated.

\* Oestrone (oeto-hydroxy-oestrin) is at present one of the more readily available and most commonly used of the oestrus-producing female sex hormones to which the general term "oestrin" was applied before their chemical nature had been elucidated. Where the term "oestrin" is used in the present paper it should be taken to mean oestrus-producing female sex hormones in general.

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## INHIBITION AND INDUCTION OF UTERINE BLEEDING BY MEANS OF

By S. ZUCKERMAN, D.Sc.Lond., M.R.C.S.Eng.  
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The increasing clinical importance of oestrogen in the treatment of conditions such as amenorrhoea or sterility resulting from uterine hypoplasia makes it necessary that the available data about the physiological action of the hormone on the endometrium

should be properly understood. At the present time two apparently conflicting statements are made on this subject: the first, that the continuous injection of the hormone inhibits menstrual bleeding, and the

second, that uterine bleeding occurs, even in ovariectomized human beings and monkeys, during the course of prolonged oestrin treatment. The purpose

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The normal histological effects of oestrin on the

primate endometrium have also been elucidated. The hormone, in castrated subjects, promotes considerable mitotic activity in the uterine epithelium.

\* Estrone (3-oxo- $\Delta^4$ -estr-1-en-17 $\beta$ -ol) is at present one of the more readily available and most commonly used of the estrus-producing female sex hormones to which the general term "estrin" was applied before their chemical nature had been elucidated. Where the term "estrin" is used in the present paper it should be taken to mean estrus-producing female sex hormones.

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# THE CAUSATION OF PNEUMOCONIOSIS\*

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THERE are four different types of reaction produced in man by the inhalation of dust. The first and most important are the pneumoconioses, such as silicosis and asbestosis, which cause specific lung pathology and often are followed by pulmonary tuberculosis. The second type of reaction is caused by toxic dusts like lead, cadmium, and radium. A third type of malady follows the inhalation of finely divided metallic fume particles such as zinc oxide and is known as metal fume fever. Finally, the fourth reaction, allergic in character, is caused by breathing organic dusts such as pollen and certain types of pulverized wood and flour. In all four instances dust inhalation can be the sole cause of the disability but with the toxic dusts characteristic reactions result from swallowing as well as from inhalation. The latter route, however, is much the more important.

In the present instance we are concerned only with the pneumoconioses which result solely from the action of inhaled dust upon the lung tissue. Of necessity then, the dust particles must

be small enough to float about in the air and be carried by rather slight air currents; otherwise they cannot be inhaled.

The modern word, *pneumoconiosis*, is a shortening of Zenker's original *pneumonokoniosis*. Zenker (1) depicted lungs definitely damaged by dust particles, but today pneumoconiosis is generally used to describe any lung which has been dusted to more than the normal degree—there need not necessarily be demonstrable lung pathology. Silicosis, asbestosis, anthracosis, anthracosis-silicosis, and similar terms indicate the different causative agents (silica, asbestos, and coal) in various kinds of pneumoconiosis.

The International Silicosis Conference in 1930 (2) defined silicosis as a "pathological condition of the lungs due to the inhalation of free silica ( $\text{SiO}_2$ )". The American Public Health Association (3) described it as a "disease due to breathing air containing silica." Sayers and Jones (4) state that "from the viewpoint of etiology, the harmfulness of a given dust containing free silica is directly influenced by the number of particles of free silica less than 10 microns in diameter that it contains". Collis has claimed for years that free silica, especially quartz, was the all-important

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factor. In summarizing his South African experience, Watkins-Pitchford (5) wrote in 1927 that dusts other than silica could "give rise to such non-permanent and relatively harmless conditions—one can hardly call them diseases—as anthracosis, aluminosis, siderosis etc".

In figure 1 are shown data from Collis indicating the etiological importance of free silica. The U. S. Public Health Service's data (6),

opal, which is non-crystalline, have not as yet been appraised hygienically and there are no statistical studies to show the relative potency of the various forms of pure silica.

**Silicates.**—Silicosis is a word suggested by Badham (7) to describe a lung fibrosis caused by dusts in which silicates and not free silica predominate. The distinction between free and combined silica is best shown by a simple example: A granite dust (8)

OCCUPATION	QUARTZ CONTENT OF DUST	PERCENT DEATHS FROM PULMONARY TUBERCULOSIS
FLINT WHIPPERS (Brooming)	100%	77.5%
GRINDERS (Sheffield)	50 to 100%	43.7%
GRANITE-CUTTERS (He. and M.H.)	30%	47.5%
POTTERS	Carbide processes only	18.9%
COAL-MINING	.....	3.9%

FIG. 1.—Mortality from pulmonary tuberculosis in various dusty trades. (After Collis)

shown in table 1, emphasize still further the importance of free silica. Silica—Silica occurs most commonly as the mineral, quartz, which is a natural contaminant of most ores, occurs in many rocks, and is found in a fairly pure state as beach sand, chert, flint, sandstone, gritstone, ganister, quartzite, and Jasper.

Quartz is a hard crystalline mineral which is weakly birefringent, that is, its two indexes of refraction are near together. Chemically it is very inert and inactive. In fact its hardness and inertness are the two properties which make it especially useful in industry. Other varieties of pure silica such as

might have the following mineral composition:

	Per cent
Pyroxene (orthoclase).....	70
Quartz.....	25
Mica (muscovite).....	5
	100

Chemical analysis of this granite would give the following result:

	Per cent
$\text{SiO}_2$ (total).....	72.55
$\text{Al}_2\text{O}_3$ .....	14.80
$\text{K}_2\text{O}$ .....	12.42
$\text{H}_2\text{O}$ .....	0.33
	100.00

TABLE 1  
SUMMARY OF THE SIX DUST STUDIES BY THE U. S. PUBLIC HEALTH SERVICE SHOWING THE DUST CONCENTRATION, COMPOSITION AND THE RESULTING HAZARD\*

OCCUPATION	ATLAS DUST CONCENTRATION (mg./cu. ft.)	ATLAS DUST COMPOSITION (per cent)	OTHER CHARACTERISTICS OF DUST	SCOPE OF HAZARD (TYPE OF DISEASE AND PERIOD OF INCUBATION)
Quartz cutting: Hand-pneumatic tool operators.....	30	Balance mostly combined silica		Greatest extent of pulmonary tuberculosis after 15 years or more exposure; silicosis in from 2 to 10 years. Silicosis after prolonged exposure; no cases of tuberculosis
Surface-machine operators, etc.....	30			Negative except for occasional nondiagnosing silicosis
Gravel air.....	20			
Less than general air.....	9			
Anthracite coal: Rock drillers.....	82	21 Siliceous rock		Data insufficient; other studies show severe hazard
Miners and miners' helpers.....	202	1.5 Carbon and inorganic matter		Dyspnea and other signs of pneumoconiosis; cases diagnosed from respiratory conditions; cases mortality from influenza, pneumonia and possibly tuberculosis
Siliceous sand: Rock drillers.....	75	54 Sandstone		Data insufficient; other studies indicate severe hazard
Loaders and machine men.....	112	1.2 Carbon		Generalized fibrosis chiefly linear in character; cases mortality from influenza and pneumonia
Cement.....	25	6-8 Primarily lime		Some early pneumoconiosis; cases of disease of upper respiratory tract and of influenza
Cotton-cloth manufacturing.....	7	7 Vegetable and silica		Negative
Silverware manufacturing.....	5	1.7 Metal and other		Negative
Municipal.....	4	7 Not determined		Negative

\*After Thompson, et al.



Recently Jones (9) showed that sericite was the outstanding common mineral constituent of a considerable series of lungs he analyzed. Sericite is a variety of mica with the formula  $K_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$ . Its occurrence in nature is widespread but the quantities actually found are much less than those of quartz. It has not been shown that sericite, without quartz, will produce silicotic pathology; all investigations along such lines have been negative.

Asbestos is the only silicate at present recognized as causing pathology which is definitely and distinctly different from that due to silica alone. The condition known as asbestosis, like silicosis, predisposes to tuberculosis but to a much less degree. Since, however, asbestos is handled by far fewer persons than are dusts containing free silica, asbestosis is much less common than silicosis.

Asbestos is not a true mineral but is a name applied to any mineral which is easily separable into more or less flexible fibers. In this country, the commonest asbestos is the fibrous variety of serpentine in the form of the mineral chrysotile,  $3MgO \cdot 2SiO_2 \cdot 2H_2O$ .

Other silicates such as talc,  $3MgO \cdot 4SiO_2 \cdot H_2O$ , which resembles asbestos chemically, shale, kaolin,  $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ , feldspar, and pure mica have been studied in both the field and the laboratory. The pathology they produce is much less significant than that from quartz and the fibrosis rarely is disabling.

Carbon.—An extensive examination of coal miners' lungs was made by Cummins and Sladden (10) as the result of which they wrote that "coal is only retained in large amounts when

there is a really high silica content" and "we believe that in the absence of the silica factor there would be, under modern mining conditions, no serious degree of anthracosis. . . . Men who were engaged in trimming coal ships with virtually no quartz exposure but undoubtedly with very heavy dust exposure, showed some fibrosis but it was not considered disabling (11).

The study made by the U. S. Public Health Service (12) in the anthracite mining district of Pennsylvania adds much weight to statements quoted from Cummins and Sladden, namely, that the harmfulness of a coal dust varies with the silica which contaminates the coal.

Haldane considered that coal dust might even reduce the severity of a quartz dust exposure; he suggested actually blowing coal dust into a mine with high quartz content as an antidote for the quartz dust (13) but no serious attempt, apparently was ever made to test the validity of Haldane's claims. The recent statistical analysis of lungs autopsied in the Pittsburgh district (14) shows beyond doubt that city air, contaminated by an unusual amount of coal dust, does not produce a disabling fibrosis. Many of the lungs were markedly pigmented but the pathology found was not, in general, significant.

Calcium and magnesium carbonates.—These substances occur in nature as the minerals calcite,  $CaCO_3$ , magnesite,  $MgCO_3$ , and dolomite,  $CaCO_3 \cdot MgCO_3$ . Limestone and marble contain high percentages of calcite while the bulk of the rock from which cement is made consists of these carbonates. All three minerals are a great deal more soluble in water and in body fluids than

is quartz. Furthermore the solubility of all three substances increases greatly if the solvent is saturated with carbon dioxide, a condition which occurs in the lung fluid which wets inhaled dust.

The several studies which have been made on calcium carbonate dusts indicate that the dusts are not harmful probably because they are so readily dissolved (8).

Gypsum.—This mineral,  $CaSO_4 \cdot 2H_2O$ , is very common and is mined and milled all over the civilized world. It is an essential ingredient of ordinary plaster and is now used extensively as a wall board. When partially dehydrated it again takes up water readily, but in neither that state nor as the native substance has it been shown to be harmful (15). It is an interesting fact that pure limestone (quartz free), dolomite, and gypsum are recognized universally as the dusts safest (hygienically) to blow into soft coal mines to prevent explosions.

Iron Oxides.—The mining of iron, next to coal, is perhaps the greatest industry in which the greatest number of men are employed throughout the world. The ore generally is hematite,  $Fe_2O_3$ , but other oxides, and sometimes the sulfide, pyrites,  $FeS_2$ , are handled on a considerable scale. As a result of the improvements made in machine-tool steel, it is possible today to see iron dust created by work on lathes, drills, and the like. Yet there are no data to indicate that iron, in the absence of silica, causes pathology in any way comparable to silicosis. However, lungs which have been heavily dusted with iron in any form are generally colored distinctively and were called by Zenker (1) *siderotic*.

#### ESTIMATION OF DUST EXPOSURE

The effect of any inhaled dust varies more or less directly with the duration of the exposure, the dust concentration and the volume of air breathed. In the case of the gas, carbon monoxide, our knowledge of the relationship of these factors is sufficiently exact to permit the use of a simple rule (16) for predicting the effects of breathing various gas concentrations under various conditions. Unfortunately, one cannot estimate or predict the severity of dust exposures with any such nicety.

In cases where men work for a number of years at different jobs with differing degrees of dustiness Bloomfield and DallaValle (17) compute exposure by averaging dustiness in these various jobs over the total period in question. In their anthracite coal dust study they found that computations so made agreed well with the results of the physical and x-ray examinations of the men. A typical example of their method of computing dust exposure is reproduced in table 2.

The advantage of these estimates lies in their simplicity and the fact that they have proven useful in correlating dustiness with physical examinations. The error in such calculations is that the effects of dust do not vary exactly, but only very approximately, with the dust concentration and with the exposure. Thus, Mavrogordato (18) writes that "lesions of silicosis in a mild degree can be produced in an animal by 30 hr. exposure to intense dust clouds, and one is inclined to suspect that it is intermittent exposure to relatively dense clouds that is the deciding factor in producing the disease in susceptible human subjects." These momentary excesses of dust-

ness Mavrogordato named dust floods. Bloomfield and DallaValle's calculations of necessity ignore dust floods and use only figures of average dustiness.

#### THE VALUE OF DUST SAMPLES

The purpose of dust sampling is to make possible the control or elimination of dustiness rather than to obtain a precise measure of dust concentration. Conditions may vary greatly almost from moment to moment and

are of dustiness and is in reasonable agreement with Mavrogordato's "figures of merit" as obtained by konimeter samples.

A great deal of time can be saved by ignoring samples which are obviously too dusty—it is as well to take the sample for a matter of record but it is absurd to work long over it if it is certain to be vastly in excess of the objective. Mavrogordato dismisses such samples with the laconic symbols "T.M.C." (too many to count).

TABLE 2

EXAMPLE OF METHOD USED IN DETERMINING AN EMPLOYEE'S TOTAL DUST EXPOSURE\*

OCCUPATION	YEARS IN OCCUPATION	ATMOSPHERIC DUST CONCENTRATION, MILLIGRAMS PER CUBIC FOOT	MILLIGRAMS OF PARTICLES INHALED PER CUBIC FOOT
Slate picker (dry breaker).....	2	300	750
Patcher (dry mine).....	2	71	142
Mule driver (dry mine).....	3	71	213
Miner's laborer (chamber).....	3	450	1440
Miner (chamber mining).....	3	450	7200
Section foreman.....	5	7	35
<b>Totals.....</b>	<b>30</b>		<b>9790</b>

9790 milligrams of particle years per cubic foot = 326 milligrams of particles per cubic foot 30 years

\* After Bloomfield and DallaValle.

only occasionally are they reasonably constant during a working shift. In general, then, it is advisable to give the results of the final estimate with an indication of the expected variation. "Thus, as a means of classifying processes according to their respective health hazards, it appears to be unnecessary to arrange them in concentration groups closer than 100 per cent, i.e., 0 to 5, 5 to 10, 10 to 20, 20 to 40, etc." (8). Such an arrangement is consistent with the few American data we now have on stand-

On the other hand, it is well to have records which indicate that the environment is as clean as is desired. In our own experience the ignoring of such samples has raised difficulties in proving in court that adequate dust control had been enforced. There is no doubt whatever that, in the United States at least, dust samples now have a very definite place in depicting working conditions to compensation boards or to a court. Under the circumstances, it is very unwise in making surveys to ignore the clean places.

#### Methods of Sampling

Dustiness is given gravimetrically if the dust is to be determined chemically and by counts if the chemical determination is especially difficult. Thus, lead is always recorded in milligrams per cubic meter but dust which may cause silicosis is given in particles per cubic foot or per cubic centimeter.

Sometimes one may wish to convert one set of readings into the other. If the dust particles are perfectly uniform and of definite shape such as spheres or cubes and of known composition the conversions can be made with precision. In such a case, it does not matter how dustiness is recorded. But in practice the dust particles are never uniform in size and rarely in composition. Conversions are, therefore, apt to be misleading. For practical work, 1 mg. of fine quartz as collected by the impinger contains 300 million particles (by the light-field counting technique).

A great deal of energy is being wasted in deciding which dust sampling method is best. The rapidity with which new methods are appearing, each claiming unusual points of merit, indicates that standardization is unlikely. An international agreement on a reference standard would be welcomed by all working in this field but, at present, such an agreement seems to be far off.

In the United States the impinger technic is most used, largely because our only extensive field data come from the Public Health Service whose workers favor this instrument. If one wishes to compare his results with those of the Public Health Service he must copy their technic. But copying the Public Health Service's technic for

the sake of the legal prestige thus gained has its drawbacks. We know of one case where a gasoline motor-driven generator and electric pump mounted on a mine car and hauled by tractor, with three men in attendance, resulted in obtaining only four samples in one day.

In South Africa where dust sampling has been done on a scale far beyond anything attempted elsewhere the konimeter and sugar tube both have been used. In England great hopes for the new thermal precipitator have been advanced but the results published so far have added nothing significant to the data already available from methods which are less accurate. In Australia several different instruments including Owens' counter have been used while the results coming from Germany were obtained by filter methods and by a modification of Owens' counter.

In our own studies we use several different methods according to the problem. There is every reason to encourage rapid methods which are particularly applicable to routine control and to discourage the widespread use of the impinger technic except for occasional check-ups. The impinger has little to recommend it in control work while a light portable instrument, such as the konimeter, has already proven its value in practice.

#### COMPOSITION OF AIR-FLOATED DUSTS

It is rarely that one meets exposures to pure silica; generally the dust is a mixture of which the original composition either is fixed, as in granite, or variable as in most foundry and mining operations. But the composition of



the dust breathed from a mixture is seldom the same as that of the parent material.

If a dust arises from the grinding or comminution of a comparatively pure substance, such as beach sand, the resulting material must have substantially the same chemical and mineralogical analysis in all stages of particle subdivision. But if a com-

monly sample and count air-borne dust by the impinger technique and then for chemical and mineralogical analyses take samples of material which has settled on rafts which will have a quite different composition. To make bad matters worse, samples for mineralogical and chemical analysis usually have not been graded into various sizes.

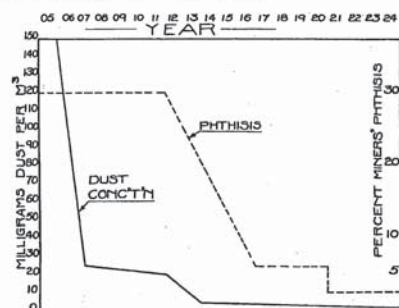


FIG. 2.—Dust control and silicosis in South African gold mines (adapted from Mavrogordato).

plex material like granite is ground and the dust then scattered in the air, samples of different particle size will have very different composition.

Many examples of the changes in composition of air-borne dust can be found in the literature to prove these statements but it is interesting that the facts generally have been ignored. Thus, in this country, investigators

Jones (19) has given indisputable proof of the carelessness of which most of us have been guilty in recording the composition of air floated dusts. In support of Jones' contentions an interesting example is given by Drinker and Hatch (8) for foundry dusts. "A good molding sand is made up of about 80 per cent quartz in the shape of coarse particles; the bulk of the re-

maining material is clay in the form of fine particles which coat the coarse quartz grains. The chemical composition of the finer fraction (say below 10 microns) of material in foundry sand is markedly different from the composition of the coarse fraction." Thus, the original material contains about 78 per cent quartz, while particles above 10 microns have 85 per cent quartz and those below 10 microns have only 19 per cent (see table 3). Under the present methods of estimating dust composition and dust hazards a large error obviously would be made by assuming that the

changes in the composition of Barre granite, of 35 per cent original quartz composition, and of various coal-silica mixtures take place on settlement in air. Obviously, changes will occur (probably great changes) but they have not been measured as yet although we have all welcomed the figures of reasonable dustiness suggested by the U. S. Public Health Service for the two industries in question, granite cutting and coal mining. Their analyses were all made from samples which had settled out on rafts, and no samples were separated into various particle size fractions.

TABLE 3  
COMPOSITION OF COARSE AND FINE FRACTIONS OF UNBLENDED FOUNDRY SAND (CONTAINING NATURAL BOND)

CONSTITUENT	PERCENTAGE BY WEIGHT		
	Total sample	>10 $\mu$	<10 $\mu$
Combustible.....	2.3	0.7	12.7
HCl soluble.....	5.5	1.6	30.5
H <sub>2</sub> SiF <sub>6</sub> soluble (clay).....	16.0	12.7	37.5
Residue (quartz).....	76.3	85.0	19.2
Total.....	100.0	100.0	100.0

original material represented the fine air floated dust.

Another example is given by Jones (19) from the South African "banket"—large crystals of quartz held together by fibrous sericite. In figure 3 are illustrated the changes in dust composition which he noted as the dust was allowed to settle, as it would in practice. Obviously, the quartz content decreases as the sericite increases. Jones remarks that "when a wall built of quartz boulders is pulled down, the bulk of the dust comes not from the quartz boulders but from the mortar."

It would be interesting to know what

#### Particle Size

It is well known that in silicotic lungs dust particles under 3 microns vastly outnumber those which are larger. It has been alleged that the respiratory mechanism, the lungs, and the phagocytes are mostly responsible for this size grading. However, it is easy to show that the size grading is done in the air before the dust is breathed and not later in the human body. That is, we find an excess of small particles in the lungs simply because that is the way that they occur in air. It is physically impossible for any but particles below 5 microns

to remain aloft in air long enough to be carried about by gentle air currents and to be inhaled. It is perfectly true that the alveoli are large enough to

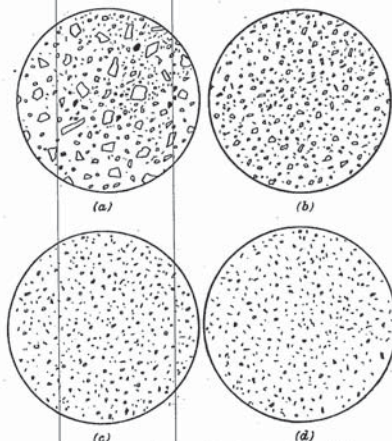


FIG. 3.—Sketches illustrating the increase in the ratio of fibers of sericite to quartz particles at different periods after blasting in a Witwatersrand gold mine. (a) about 15 minutes after blasting; (b) about 1 hour after blasting; (c) about 2 1/2 hours after blasting; and (d) about 3 hours after blasting. (After Jones, courtesy Inst. Mining and Metallurgy.)

admit particles 100 or even 200 microns in length and that such particles are occasionally found in lungs (20). But the reason that they are found in lungs so infrequently is that they

are all of the order of those found in lungs and in phagocytes.

Gyo and Kettle (22) showed that colloidal silica was extremely toxic and that it could initiate fibrosis. It

is claimed occasionally that the damage done by quartz particles is due entirely to those which approach the colloidal in size. Usually particles possessing colloidal as distinguished from crystalline properties are considered to be less than 0.1 micron in size. All colloidal particles are so small that they can be measured only ultra-microscopically.

There is no evidence indicating that appreciable or significant quantities of ultra-microscopic quartz can be made by any known process of grinding or comminution, including blasting. In fact, the difficulty of preparing even small specimens of quartz below 0.5 microns is considerable. Furthermore, there are no published data indicating the relative potency of quartz particles in various sizes below 3 microns. Under the circumstances, then, there is no good reason to blame colloidal particles as the initiators of the silicotic nodule when it has been demonstrated again and again that such nodules can be produced by particles approximating the common bacteria in size.

#### Standards of Dustiness

Under one name or another the plant or mine manager always wants an objective for his dust control program. It serves no useful purpose to evade the issue on the ground that precise figures are not available. Probably they never will be. The practical man argues, very properly, that if dust is the cause of silicosis there must be some degree of dustiness or of air cleanliness which is safe. Having been told that silicosis is a disease caused by breathing silica, the practical operating man naturally ex-

pects of the physician or hygienist some objective of air cleanliness, call it by whatever name one likes.

In this country the U. S. Public Health Service studies have furnished the only published data we have from which we may suggest dust standards. In the case of Barre granite it was pointed out that a dustiness of 10-20 million particles per cubic foot was reasonably certain not to cause disability. The coarse dust, in this case, contained about 35 per cent quartz. In their recent anthracite coal study the Public Health Service found that counts of 50 million per cubic foot, with 5 per cent quartz in the coarse dust, seemed safe.

In the case of pure quartz Cummings (4) suggests a figure of 5 million particles per cubic foot which is not far from the South African figure of 1 milligram per cubic meter (figure 3). We have then 50 million for dust with less than 5 per cent quartz and 5 million for pure quartz. It is very questionable if one has any right to interpolate for the quartz percentages between 50 and 5 but the figures certainly invite such interpolation.

These standards do not answer the question of the plant which handles dust of no proven pulmonary significance. What standard should the manager of such a plant take as his objective or need he take any precautions at all? We cannot give him any standards but we can only suggest that he investigate one of the many plants which has reduced dustiness without waiting for any physiological justification. Generally the manager and workmen of a clean plant will uphold eloquently the advantages of dust control.



It is only in South Africa that dustiness and silicosis have been correlated routinely over a considerable period. There they realized at the outset that dustiness would not be controlled properly unless measured and recorded routinely. Concerning the results of their procedure, Irvine (23), Chairman of the Miners' Phtisis Medical Bureau in 1934, stated that "No 'New Rand Miner' who has entered the industry since August, 1923, i.e. 10½ years ago, has as yet contracted silicosis. These facts demonstrate that the engineering and medical measures which have been directed against silicosis have achieved a very significant degree of success." It would be hard to devise a more eloquent or complete proof of the advantage of dust sampling and of dust standards.

## SUMMARY

The various pneumoconioses and their causative agents are discussed.

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## CLINICAL ASPECTS, DIAGNOSIS AND TREATMENT OF PNEUMOCONIOSIS\*

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THERE are two types of dust which may cause some degree of pneumoconiosis; these have been termed inert and active dusts. The determination as to whether or not a dust is active or inert has been reached by pathological examination of the lungs of those dying of pneumoconiosis, by clinical studies, especially x-ray, and by animal experimentation.

## REVIEW OF ANIMAL EXPERIMENTS

The study by animal experimentation has been particularly valuable as it provides a method of determining the effect of a given dust upon the living tissues and a comparison with the effect of similar exposure to other dusts. The animals used have been white rats, rabbits, guinea pigs, monkeys, fowl, cats, and, for some experiments, tadpoles and fish (1, p. 44).

The methods used have been:

1. Dusting.—This consists in exposing the experimental animal to a "high concentration of dust (up to 10 or 12 billion particles per cu. ft. of air, dark-field) to produce maximum effects in short time." This method

might be called the normal breathing method.

2. Injection of suspensions of dusts.

—This consists in injecting suspensions of dusts into various parts of animals to detect the capacities of different dusts to provoke reaction in the tissues. Results are obtained more rapidly than by dusting but do not correctly show the natural development of disease in the lungs.

The dust suspensions may be introduced into the animal by:

1. Intratracheal or bronchoscopic injections.
2. Intraperitoneal injections (Miller-Sayers method (2)).
3. Subcutaneous injections.
4. Intravenous injections—showing the effects of the dust on the extrapulmonary viscera.
5. Intracutaneous injections—for gross reaction.

6. Intra-lymphatic injections—for reaction of lymph node cells (3).

All animals tested either by dusting or by injection showed a tissue reaction to silica. This reaction was typified by the formation of fibrotic nodules except in the cold blooded animals where there was necrosis followed by some fibrosis. Changes in susceptibility of animals to tuberculosis as a result of the effects of various dusts have also been studied, and the

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activating effect of silica demonstrated.

The effect of the inert dusts upon the animal tissue was found similar to that of any foreign body. There was reactionary enlargement of lymphatic nodes, slight fibrotic reaction immediately surrounding the injected dust but no continuation of this fibrosis and no formation of nodules. The exact pathology noted was scattered or clumped cells containing the inert dust lying in the alveoli, slight inflammation or no inflammation of the adjacent walls, a slow accumulation of dust-containing cells in the lymph nodes with enlargement of the nodes, and a deposition of dust about the lymphatics of the lung or pleura. When inert substances were injected intravenously, intraperitoneally or subcutaneously, there was no reaction beyond that of any foreign body (2).

As a result of such experiments which have been repeated in many parts of the world, it is believed that of all suspected dusts only silica has a specific action upon animal tissue which results in fibrotic nodulation. Asbestos fibres produce a peculiar reaction in the lung which is different from silica. Following the inhalation of asbestos dust there are formed "cuffs of more dense connective tissue about the terminal bronchioles" (1, p. 46). Contraction and collapse of the alveoli supplied by the affected bronchioles occurs. This is followed by induration and fibrosis of the collapsed alveoli, presenting the picture of diffuse fibrosis of parts of the affected lung with persistent foci of normal air spaces.

#### SILICOSES

The Committee on Pneumoconiosis and the Committee on Standards of the American Public Health Association (4) adopted in 1932 the following definition: "Silicosis is a disease due to breathing air containing silica ( $\text{SiO}_2$ ) characterized anatomically by generalized fibrotic changes and the development of military nodulation in both lungs, and clinically by shortness of breath, decreased chest expansion, lessened capacity for work, absence of fever, increased susceptibility to tuberculosis, (some or all of which symptoms may be present) and by characteristic x-ray findings."

#### I. Pathology of Silicosis

Dust particles after reaching the lung alveoli may remain quiescent for a considerable period as is the case with the inert dusts, or they may penetrate the lymph spaces in small numbers. The bulk, however, are phagocytosed, that is engulfed, by wandering endothelial cells which at first, lining the wall of the alveolus, become detached, and then, having taken up the dust particles, pass by amoeboid movement through the walls of the alveolus into the lymph spaces. The cells now slowly migrate to the minute lymph islands which guard the entrance to the small lymphatic vessels, pass through these, thence to the lymph vessels, and finally are caught by the large group of lymphatic glands which form part of the hilus or root of the lung. These wandering cells are commonly called dust cells.

The piling up of cells and the reaction of the glands blocks the free circu-

lation of lymph so that the dust cells tend to move slowly toward the lung roots, blocking the lymph vessels and later the minute lymph masses which guard the entrance to the lymph vessels. The dust cells which are killed by the silica disintegrate and free the silica dust for further injury to the neighboring tissues. The reaction of the tissues to silica is the production of fibrous tissue. Thus fibrous tissue forms along the lymphatic vessels which accompany the blood vessels of the lung, invades the septa between the lobes, and spreads its shoots into the lung tissue itself. The minute masses of lymphatic tissue become fibrotic nodules and these, as time goes on, increase in number to such an extent that, combined with the fibrous tissue of the former lymph channels, conglomerate masses of fibrous tissue are formed, blocking off large portions of the lungs. The blocking of the lymph flow toward the hilus increases the spread of dust cells to the pleura and eventually leads to fibrosis of this structure.

The fibrotic nodule is characteristic of silicosis. It is a small, discrete hyaline mass surrounded by apparently normal lung. It does not exceed 6 mm. in diameter. "Occasionally some of these nodules may show microscopic foci of central necrosis" (1, p. 146).

This increasing amount of fibrous tissue obliterates the alveoli and provokes a compensatory enlargement of the alveoli elsewhere. This condition of enlargement is called emphysema. As the amount of air space is insufficient to permit the normal oxygen-carbon dioxide interchange of the lungs

required by the body, the effort of the heart to pump blood fast enough may promote enlargement of that vital organ. This, however, if it occurs, is a terminal condition infrequently observed, as the patient usually develops pulmonary tuberculosis or dies of an intercurrent disease before this stage is reached. It must be remembered that only one-fourth of one lung is necessary for life, and that the amount of fibrosis must be enormous to restrict the lung capacity to this extent.

#### II. Symptoms

The effect of the underlying pathology upon the workman is at first too slight to be detected by physical examination and the worker shows no symptoms. While there is a pathological condition present, it is to all intents and purposes harmless, in that if it does not progress rapidly it may not provoke symptoms during a worker's life, or only during the last decade. Even respiratory disease of another nature, such as bronchitis or even pneumonia, may occur with recovery during this period.

As the condition progresses, however, more and more of the lung tissue is converted into fibrous tissue, and the patient begins to show certain symptoms. He complains of shortness of breath when he goes up-hill and says that he notices his heart beat on exertion. He also mentions a cough which is at first dry and infrequent, but which gradually becomes moist and frequent. With the cough he raises scanty, stringy sputum which is sometimes discolored. The sputum is never large in amount unless he catches cold and develops bronchitis. At this

stage an attack of bronchitis does not disappear but becomes chronic. During this period the silicotic may complain of pain in the chest due to pleurisy or to epigastric pain, anorexia, and morning vomiting. While he is able to work, the victim cannot carry on his usual tasks and seeks lighter work.

Slowly the shortness of breath increases, the patient has poor lung expansion, and his color becomes pale and his lips bluish.

At this stage pulmonary tuberculosis is a frequent complication. When this occurs, the cough becomes more severe and continuous, the sputum free and moist, areas of dullness to percussion are noted, rales are heard over the chest on physical examination, and cavitation may be detected. Tubercle bacilli may or may not be present in the sputum. Many of these cases are able to carry on light work for years before finally succumbing. Hemorrhage from the lungs occasionally occurs.

During the early stages when perivascular, peribronchial, lymph node reaction is present there are only indefinite physical signs. Irvine (5) describes these as follows:

1. A certain lack of elasticity of the chest wall during movements of respiration together with
2. A somewhat reduced air entry, and
3. A characteristic alteration of the inspiratory murmur from the normal vesicular character to a higher pitched or "harshened," thinned and commonly somewhat shortened type, the expiratory murmur although somewhat prolonged remaining fainter than the inspiratory.

There is little change in these signs as the disease progresses. "The per-

cussion note is somewhat flattened without being definitely dull especially posteriorly. Breath sounds have more definite characteristic thinning, the expiration being longer and fainter" (6). With the advent of tuberculosis the physical signs are those of that disease.

#### III. X-ray

The most important evidence of silicosis is obtained by x-ray. While a flat film gives valuable information, an accurate diagnosis requires a stereoscopic set of films. In many cases a lateral film is desirable in order to determine the amount of emphysema present and the size of the heart. Fluoroscopic examination is of interest in cases where diaphragmatic adhesions are suspected or shown on the film.

The old classification into first, second and third stages has been recently changed to a more descriptive nomenclature. The conditions noted on the film are now called:

1. Stage of perivascular, peribronchial, lymph node proliferation. Irregular exaggeration of linear markings.
2. Stage of nodulation.
3. Stage of fibrosis with conglomerate masses.
4. Any of above stages complicated by shadows characteristic of tuberculosis.

The first is not considered as diagnostic of silicosis as it may occur in persons who are in good health or in a number of pathological conditions which have nothing to do with silicosis.

The stage of nodulation is pathognomonic of silicosis but may be confused with films of military tuberculosis.

The stage of fibrosis with conglomerate masses may be confused with fibroid phthisis.

#### IV. Diagnosis

Diagnosis is made upon:

1. Occupational history with estimated length of exposure, quality of dust and quantity of dust.
2. Physical examination.
3. X-ray examination.
4. Presence or absence of tuberculosis as a complication.

Of these measures the first and third are most important. Probably the most difficult thing to decide is whether or not tuberculosis is present. Absence of fever and maintenance of weight, with absence of physical signs suggesting active inflammation in the chest, is indicative of simple silicosis.

The absence of tubercle bacilli from the sputum is inconclusive, as many cases of silico-tuberculosis fail to show bacilli in the sputum.

#### V. Progress

Silicosis once established in the lung has a strong tendency to progress. This appears to be owing to the toxic properties of the silica particle. What causes this toxic action is still in doubt. "Experiments and human pathological material indicate that in high concentrations silica is toxic and kills tissue; prolonged action of lower concentrations cause proliferation and fibrosis" (1, p. 46).

In spite of the fact that quartz is generally recognized as relatively insoluble, there is great rapidity of development of body reactions to silica. "Possibly unexplored properties of silica, electrical charge, adsorption etc., are concerned" (1, p. 48). This

progressive tendency has been noted by Irvine, Böhm, Russell and others (1, p. 28).

The question is not what is the present condition of the silicotic, but how rapidly it will advance and how far. This is a serious problem in industry, for a worker having no symptoms and an early stage pathology by x-ray, may develop a disabling silicosis or a complicating tuberculosis. It is, therefore, possible for a worker to contract his disease while working for one employer and to develop symptoms many years later while working for another. If the work he is doing for the second employer involves exposure to an inert dust the employer may have difficulty in proving that this was not the cause of disability.

One of the striking differences between the effects of the inert dusts and silica dust is the lack of progress of pathology in the former as compared with the latter. Böhm (7) found that silicosis progressed after removal from exposure in 20 per cent of the cases diagnosed as having silicosis grade 1, in 40 per cent of the cases in grade 2 and in practically all the cases in grade 3. The experience of the State of Wisconsin, however, suggests that silicosis detected at an early stage in many cases will not progress if the worker is transferred to non-dusty work (8) though the reports of Watkins-Pitchford (9) and Britton and Head (10) make this somewhat doubtful.

Infection may play a part in the development. In fact, it is the frequent and serious complication of silicosis, and of the common infections, pulmonary tuberculosis is by far the most serious.



Tuberculosis may develop early or late in the disease. In those who have an inactive focus in the lung, the silica dust may change the condition to one of activity, or in cases of well-developed silicosis, tuberculosis may be superimposed upon the silicotic fibrosis.

Thus Kettle writes, "harmful dusts if inhaled into the lung may excite to activity a latent tuberculosis infection; they may exaggerate an active tuberculosis lesion or a coincident infection; and they may render the lung less able to cope with a superimposed infection" (11).

The course of silicosis with a secondary tuberculosis is usually slow and without the usual symptoms of intoxication and may be carried for years without serious impairment of working capacity.

While tuberculosis is the most frequent complication and cause of death, other infections do occur. On the Rand pneumonia is a common cause of disability and death. Pope and Zacks found pneumonia occurring with great frequency among foundry workers in Massachusetts. Proke and Savers have confirmed Cummings' discovery of fuso-spiracheta organisms as a cause of infection among miners in Fisher, while chronic bronchitis with asthma is fairly common (12, p. 47).

Collis and Yule (13) compared the mortality experience of an occupational group exposed to silica dust with that of the general population, and with that of an occupational group exposed to dust not containing silica. As a result of the study, they concluded that silica is a body poison like lead. Even though it exerts its primary injurious effects on the re-

spiratory tract, the silica slowly invades the body, involving the circulatory system, the nervous system, the digestive organs, the kidneys and liver, and eventually causes death through its harmful effect upon one or another of these organs.

#### ASBESTOSIS

"Asbestosis is a pneumoconiosis caused by the inhalation of asbestos dust. It is distinct from silicosis both in its pathology and clinically. Asbestos is a hydrated magnesium silicate containing no free silica but about 44 per cent of combined silica, 43 per cent magnesium, nearly 13 per cent of water and traces of iron and nickel" (14).

#### I. Pathology of Asbestosis

Asbestos dust differs from other inhalable dusts in that it exists in thread-like fibres in which the diameter may be very small (5 microns or less) but which may be many microns in length.

These dust fibres do not appear to enter the alveoli. They are stopped at the neck of the alveolus where they are phagocytosed or penetrate the tissues. Acting specifically or merely as a foreign body they become surrounded first by mononuclear phagocytes, later by giant cells and last by fibrous tissue. There is no migration in dust cells to the lymphatics and lymph nodes as is seen in silicosis. The newly formed fibrous tissue contracts, constricting the neck of the alveolus so that no air can enter. Collapse of the alveolus follows and subsequent fibrosis.

In this way the lower parts of the lungs are filled with interstitial fibrosis and the air space markedly dimin-

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ished. A compensatory emphysema may occur in the upper part of the lungs. Thickening of the pleura over the lower half of the chest is almost always present. Tuberculosis as a complicating factor is not common.

The asbestos fibre after it has become fixed at the neck of the alveolus frequently develops into a "curious body," the asbestosis body of Cooke (15). This is a long, narrow, cylindrical body, golden yellow and translucent, often with rounded ends like a dumbbell. These asbestosis bodies are found on autopsy and occasionally in the sputum. As similar bodies may occur in lungs not exposed to asbestos dust, the finding of these bodies is not diagnostic of asbestosis unless accompanied by a definite history of exposure to asbestos dust.

#### II. Symptoms of Asbestosis

The symptoms of asbestosis, like those of silicosis, are cough and dyspnea. With the cough there is sputum which may or may not contain asbestosis bodies. Hemoptysis is rare. There is loss of weight in the advanced cases, and marked reduction in the vital capacity and in chest expansion. The patient's face has an "earthy" look.

In advanced cases the dyspnea is out of proportion to the physical signs, being very severe, and is accompanied by blueness of the lips and occasionally by clubbing of the fingers. The fingers frequently show "asbestos corns" from the penetration and irritation of fine spicules of asbestos which are detached from the asbestos in handling.

#### III. Physical Examination

The patient, if an advanced case, shows loss of weight. The chest is

emphysematous, and respiration is shallow, expansion being frequently less than 1 inch. The percussion note is one of dull tympany but with no definite dullness. The breath sounds are distant and expiration prolonged. The heart is normal in size, but lateral x-ray may show an anteroposterior enlargement.

#### IV. X-ray

This shows a fine mottling of a "ground glass" quality over the lower half of the chest. There is often an obliteration of the costophrenic angle and pleural thickening, shown particularly in the interlobular pleural on the right. The lateral view may show well-marked compensatory emphysema. A spot of tuberculosis at either apex is occasional but rare.

Still later in the course of the disease the appearance is that of a very fine stippling that obliterates most of the natural markings. The pleural shadow is definitely thickened. In some of the advanced cases the heart is enlarged and radiating from it into the lung fields is a series of heavy fibrous bands. This picture has been referred to as "porcupine heart."

#### ANTHRACOSIS-SILICOSIS

This disease occurs among hard coal miners and is commonly known as miners' asthma. It is caused by the inhalation of large amounts of dust consisting of a mixture of anthracite coal and quartz, the quartz coming from the rock in which the coal is imbedded.

The pathology consists of a clogging of the lymph spaces with carbon particles which invade the upper lobes especially. Accompanying this is a linear or nodular fibrosis due to the

inhaled silica particles. When large areas of the lung are involved there is a compensatory emphysema.

#### I. Symptoms of Anthracosis-Silicosis

The cardinal symptom of anthracosis is shortness of breath, which explains the term "miners' asthma." With this there is cough and sputum. The cough may be dry and the sputum scanty but if infection in the form of bronchitis is present, the sputum is mucopurulent and colored with coal dust. As in silicosis, tuberculosis is a frequent complication.

The physical signs are similar to those of simple silicosis or of silicosis with infection. Diagnosis is made largely by x-ray which gives a picture very similar to that of simple silicosis. The U. S. Public Health study on this problem (16) suggests that the true lung injury is due to the silica inhaled rather than to the carbon particles. Carbon has been found to be harmless when inhaled in the form of smoke and by animal experiment.

#### INERT DUSTS

##### I. Pathology

The inert dusts are relatively harmless. They may increase the frequency of respiratory disease when inhaled in large amounts, but this has not as yet been proved statistically. Workers inhaling these dusts develop a mild fibrosis which follows the course of the lymphatics along the bronchoarterial tree and is accompanied by enlargement of the tracheal lymph nodes. This reaction which is very slow, after a number of years may progress to a moderate amount of interstitial thickening. The pleura may be thickened and there may be dia-

phragmatic adhesions. These later manifestations only appear after many years of constant exposure to a high concentration of dust.

#### II. Symptoms Caused by Inert Dusts

The symptoms of the pneumoconiosis of inert dusts are negligible. If the exposure has been long and the dust discharge abnormally heavy, there may be some dyspnea on moderate working. This is not usually severe enough to interfere with the worker's normal activities and may be caused by degenerative changes of the heart due to advancing age, as much as to the pathology of the lung. There is no evidence that the inert dusts, unless mixed with an active dust, can produce disability.

#### III. X-ray Picture, Physical Examination and Diagnosis

The x-ray picture is that of perivascular, peribronchial, lymph node thickening which does not progress. Some diaphragmatic adhesions may show in cases with long exposure to heavy concentrations of dust. Serial pictures fail to show nodulation or the massive areas of fibrosis which characterize silicosis.

The physical examination of those exposed to inert dusts is usually negative. In a few cases where there has been prolonged exposure to great quantities of dust there may be some restriction of chest expansion and signs of emphysema.

The diagnosis is made by physical examination, occupational history, and x-ray.

A typical inert dust is that of the artificial abrasive, aluminum oxide. This material is widely used in grind-

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ing wheels and for polishing, sand paper, etc. In the year 1929 over 71,000 tons were sold or used in plants in the United States and Canada (17).

The use of aluminum oxide creates a certain amount of dust. The effect of this dust has been studied by Clark (18) and Simmons clinically and by Gardner (19) on the experimental animal.

In a factory where artificial abrasives and grinding wheels are manufactured, Clark has studied the effects of inhalation of this substance for 25 years. He believes that in factories which provide proper dust removal, the continuous inhalation of artificial abrasive dust extending over many years of work does not produce the symptoms or present the x-ray findings of crippling fibrosis of the lung; that the number of cases of pulmonary tuberculosis does not greatly exceed the number normally present in the community; and that workers using wheels made of artificial abrasive or using this substance for polishing or other purposes run but slight risk of pneumoconiosis if excessive dust is removed by exhaust systems.

In spite of the fact that clinical and experimental evidence points to the relative harmlessness of the inert dusts, an effort should be made to keep the dust count around 20 million particles per cubic foot of air. This will make working conditions much more satisfactory to the worker and will reduce the hazard of respiratory disease.

#### TREATMENT OF PNEUMOCONIOSIS

The only method of treatment of the pneumoconiosis is prevention. Dust in quantity must be eliminated from industry wherever possible, and

in most operations this is feasible. In a few where it is not, protective devices such as respirators or positive air pressure helmets must be used by the worker.

When a worker is found upon examination to have lung fibrosis it is wise to keep him at work in a non-dusty department. While his lung condition, if it is due to silica or to asbestos dust, will progress slowly, many years of profitable work are before him unless infection intervenes. As dyspnea increases, lighter work must be provided. If tuberculosis complicates the picture and the patient develops tubercle bacilli in the sputum, he must be isolated from other workers, but even then may be able to do light outdoor work. In more severe cases where there is temperature, all work must, of course, be stopped.

#### Exposure

The rapidity of development of silicosis and of asbestosis depends upon the amount of dust inhaled and the percentage of free silica (SiO<sub>2</sub>) or of asbestos in the dust.

In men exposed to heavy dust clouds with a high concentration of silica, silicosis has developed in as little as 2 years, but under the usual exposure of mining and of industry where the free silica usually varies from 13 to 35 per cent, the development is slow and symptoms do not appear for 15 or more years.

In the case of asbestosis, the development of symptoms is more rapid, 5 to 8 years being the usual required time of exposure.

Efforts are now being made to correlate the exposure with the pathology, as shown by x-ray, and with the physi-



cal signs. In other words, an effort is being made to determine standards of permissible amounts of dust in the working air for both the inert and the harmful dusts. Such standards will be of the greatest value to industry in its effort to reduce its dust hazard to a minimum.

#### EPIDEMIOLOGY

##### I. Silicosis

The danger of inhaling inorganic dust has been recognized for centuries, but careful study of the effect of such inhalation was first instituted in South Africa and culminated in the International Conference on Silicosis held in Johannesburg in 1930.

In 1933 Van Sien (20) published an estimate of the health hazard from dust in the mines and allied industries of the United States. In his study he found that of 7722 men examined in the Tri-State zinc-lead district of southwest Missouri in 1927-28, 5704 were classified as negative for lung disease, 1362 had signs of first stage silicosis, 253 had second stage, and 32 had third stage. The remainder showed signs of tuberculosis with or without silicosis.

In Butte mines (Montana), of 1018 miners 42.4 per cent showed definite signs of dust injury to the lungs.

In the Lead-Deadwood district mines in South Dakota the sickness rates per thousand for respiratory disease was two and a half times greater than in general industry, while the tuberculosis rate was almost ten times greater.

Grouping the various industries studied, Van Sien found that in metal mining about 62,228 workers were exposed while among those engaged in

non-metallic mining or quarrying, 23,665 had a respiratory hazard.

The prevalence of silicosis in the general population was studied by Lanza and Vane in 1934 (21). They cite the following occupations as constituting a definite silicosis hazard:

1. Anthracite-coal and metal mining, quarrying.
2. Certain manufacturing industries such as potteries, glass works, and plants manufacturing granite, sand-blasting.
3. Construction work—rock drilling, handling sand and gravel.

Their rough estimate of the number of workers exposed to silica dust to a harmful degree in the United States is upward of 500,000.

A careful study of 2,600 granite and foundry workers has recently been made by Pope and Zacks (22) in which correlation of the duration of exposure to dust and the incidence of silicosis was determined. Their conclusions are as follows:

1. In representative groups of both granite and foundry workers in Massachusetts the frequency of silicosis and of silicosis with tuberculosis was found to be positively correlated with the duration of exposure to dusts containing free silica and to concentration of such dusts in the occupational environment.

2. Among the granite workers examined silicosis alone was found in 15.3 per cent and silicosis complicated with tuberculosis in 7.6 per cent.

3. Tuberculosis is the cause of death in over one-third of all granite workers, a proportionate mortality three times that in foundry workers and four times that in all males of 20 years and over.

In 1907 Simmons of the Miners' Phthisis Committee of Australia reported that gold miners there who contracted silicosis died of tuberculosis

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(23). "The initial studies of silicosis by workers in South Africa were started by a demand made upon health authorities to determine the cause of the excessive mortality from tuberculosis which was increasing at a rapid rate among the miners there."

Russell found an excessive number of deaths from tuberculosis in his Barre, Vermont study of the health of granite workers (24) and Gardner (25) believes that at least 75 per cent of those who develop silicosis contract tuberculosis.

berculosis is so often associated with silicosis that it seems probable that the association is more than accidental."

Gardner (1, p. 51) says that many autopsies show a combination of tuberculosis with silicosis and other silicate dusts but "that surveys of living American workmen show no great excess of this infection", while Lanza (28) in a study of dust conditions in asbestos mines and mills in Canada and in fabricating plants along the Atlantic seaboard found in his study

TABLE I  
SILICOSIS AND ASBESTOSIS IN GREAT BRITAIN, THROUGH 1934\*

	NUMBER OF DEATHS	AVERAGE AGE AT DEATH	PERCENTAGE OF EMPLOYMENT IN TRADE		
			Maximum	Minimum	Average
Silicosis.....	261	55.4	60	2.3	34.8
Silicosis with tuberculosis.....	315	52.5	67	2.0	32.9
Asbestosis.....	41	41.0	27	1.5	12.9
Asbestosis with tuberculosis.....	26	38.0	29	0.8	9.9

\* J. C. Bridge: Report of Chief Inspector of Factories and Workshops, London, 1934, chapter 3.

#### II. Incidence of Asbestosis

The health hazard of asbestos dust has only been recently recognized. The Regulations for the Asbestos Industry in England have been in force for only 4 years. Bridge (20) says: "Over a number of years" (number not specified) "the deaths from asbestosis reported to the Department and compiled in 1934 numbered 41 while those from asbestos and tuberculosis numbered 26". (See Table I.) Wood and Glynn began their studies on pulmonary asbestosis in 1928 and published results of the study of 109 cases in 1934 (27). Most of these cases worked in the same factory. According to Wood, "pulmonary tu-

berculosis is so often associated with asbestosis that it seems probable that the association is more than accidental."

berculosis is so often associated with asbestosis that it seems probable that the association is more than accidental."

#### SUMMARY

1. Pneumoconiosis is a disease resulting from the inhalation of inorganic dust.
2. The two pneumoconioses which produce disability are silicosis and asbestosis.

3. The pathology of silicosis is characterized by the presence of fibrotic nodules scattered through both lungs, and that of asbestosis is characterized by an interstitial fibrosis involving the lower half of both lungs.
4. The symptoms of silicosis and asbestosis are similar, the most important being dyspnea.
5. The most common complication is pulmonary tuberculosis which in silicosis is a frequent cause of death.
6. The diagnosis of both silicosis and asbestosis is made largely by a correlation of history and symptoms with the x-ray examination.
7. The treatment of pneumoconiosis is preventive and symptomatic.
8. The course of silicosis and of asbestosis is slow but eventually leads to incapacity due either to the disease itself or to a complication, frequently chronic pulmonary tuberculosis.
9. The number of workers exposed to harmful mineral dusts in mining and in industry in the United States has been estimated as 500,000.

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# CERAMIC ABSTRACTS

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## Abrasives

Abrasion at high temperature. YOSHINO FUJII. *Tetsu-to-Hagane*, 21, 550-60 (1935); *Chem. Abs.*, 29, 7898 (1935).—By use of a newly constructed abrasion tester various materials used in Diesel cylinder liners and piston rings were tested in lubricating oil at 200°. With cast iron, loss of weight reached 50 times that at room temperature. On two nitrided steels and seven C steels (0.1 to 0.9% C) the test was carried out under a load of 50 kg./sq. cm., the best results were obtained with the two nitrided steels and 0.5 to 0.6% C steel. The loss of weight in these cases reached only 1/10 to 1/100 of that of the cast iron. The temperature of the cylinder wall was estimated to be lower than 200°.

Borocarbide. ADOLF VOROT. *Oberflächenforsch.*, 13 (21) 245-46 (1935).—Borocarbide is made of boric acid and coke; both of these should be very pure and the boric acid dehydrated. It is formed at 2500 to 2600°C.

It has the formula  $B_2C$  with a structure  $\begin{array}{c} B \\ \diagup \quad \diagdown \\ C \end{array}$ . Compounds of  $B_2C$  to  $B_3C$  are solutions of the elements in  $B_2C$  or mixtures of the elements with  $B_2C$ . It is considerably harder than silicon carbide and has a hardness close to that of diamond, greater compressive strength and toughness, and an impact strength greater than that of the hardest tungsten carbide. The specific gravity is only 2.5. It has a high elasticity coefficient and a melting point of 2300 to 2500°C. The expansion coefficient is  $6.5 \times 10^{-6}$  cm./°C, similar to Si carbide. The temperature coefficient of the electric resistance is negative and similar to that of carbon. Borocarbide is chemically resistant to the strongest alkalis and acids even at elevated temperatures and will stand 1000°C with excess of air where diamond begins to burn. It is used for grinding and polishing instead of diamond, but for these purposes it must be very pure and must not contain any graphite or metallic B. It is also used for crucibles of sandblasting apparatus; the price is still very high.

M.H. Grinding edges and surfaces of refractory brick. E. PROBERT. *Schleif- & Polierzeits.*, 13 [10] 222-29 (1935).—The best way to work refractory or acid-resisting material is to use special grinding machines. P. gives data on power and time required and descriptions and dimensions of grinding disks. Advantages of different machines are dealt with. Illustrated.

P.R.V. Magnetite as a standard material for measuring grinding efficiency. R. S. DEAN. *Amer. Inst. Mining & Met. Engrs., Tech. Pub.*, No. 660, 5 pp. (Feb., 1935); *Metals & Alloys*, 7 [8] MA278 (1935).—Gross and Zimmerley (*Ceram. Abs.*, 19 [6] 448 (1931)) have proved that the energy actually used in grinding is proportional to the new surface produced. Gottschalk found that the coercive force of magnetite powder was directly proportional to surface area. To study grinding efficiency it is necessary only to charge the machine with 10-mesh magnetite and measure the power input while grinding. The coercive force of the ground sample is then determined by a simple method. Data are given to show that the method actually works.

Method of comparing the hardness of electric-furnace products and natural abrasives. CHARLES E. WOODGILL. *Trans. Electrochem. Soc. (Preprint)*, 68, 18 pp. (1935); *Chem. Abs.*, 29 [22] 8295 (1935).—The relative resistances to abrasion during lapping are measured. The results

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can be duplicated with a fair degree of accuracy. Considerable variation in hardness exists among diamonds. South American brown bort diamonds were found to be consistently harder than other types, although the South American ballas possessed a hardness which was almost identical with the bort. The carbonado diamond, which is usually considered the hardest of diamonds, was found to be considerably softer than the other varieties. The interval of hardness between corundum and the diamond is much greater than would be realized from a consideration of the Mohs' scale, and a comparative scale is given, extending from the diamond to quartz. The proposed scale based on the lapping method is as follows: bort 10, ballas 9.90, carbonado 9.82, boron carbide 9.32, black SiC 9.15, corundum 9.00.

## BULLETIN

Use of Abrasive Wheels. AMON. *Brit. Home Office Safety Pamphlet*, No. 7, 62 pp. 5th ed. H. M. Stationery Office, London, 1935. Price 9d. The great increase in the use of abrasive wheels has made the dangers incidental to their use of increased importance, especially with regard to accidents and to dust inhalation. This book is a collaboration by manufacturers and Government inspectors. Illustrated.

## PATENTS

Abrading machine. A. N. BROMOS (Porter-Cable Machine Co., Inc.). U. S. 2,099,700, Feb. 2, 1937 (June 22, 1934).

Abrasive article. BAKERITE, LTD. (Bakelite Corp.). Brit. 457,953, Dec. 23, 1936 (June 13, 1935).

Abrasive article. D. H. WINTER (Norton Co.). U. S. 2,070,764, Feb. 16, 1937 (Oct. 8, 1934). A grinding wheel comprises a substantially porous body of bonded abrasive grains having a central hole therethrough, a backing therefor composed of vulcanized hard rubber impregnating the surface pores of the abrasive body and forming an integral unit therewith which extends across the wheel hole and has a face engageable with a wheel support, a clamping plate remote from the face which is imbedded within the backing and located within the wheel hole to secure it against the wheel support, and means engageable with the plate for clamping the wheel assembly in position, whereby the backing distributes the clamping and driving forces between the wheel and its support.

Abrasive wheel. EDWARD VAN DER PYL (Norton Co.). U. S. 2,069,788, Feb. 9, 1937 (Aug. 7, 1935). The method of making a composite wheel comprises providing a thin metal disk, forming a groove in the periphery of the disk, providing an annulus of abrasive substance bonded with a suitable bond, the inside diameter of which is slightly greater than the diameter of the disk less twice the depth of the groove, opening the metal on either side of the groove, placing the disk in the annulus, and rolling or swagging the metal in place.

Air-swept grinding mill. CHRISTIAN NIELSEN (F. L. Smith & Co.). U. S. 2,069,174, Jan. 26, 1937 (July 11, 1933).

Apparatus for the manufacture of granule-coated wheels. W. J. TERNANT (Carborundum Co.). Brit. 457,462, Dec. 9, 1936 (May 27, 1935).

Automatic grinding machine. A. J. LEWIS (Hald

Machine Co.). U. S. 2,070,283, Feb. 9, 1937 (Dec. 8, 1932).

Automatic rough feed for buffing machines. R. A. SWENST (Packer Machine Co.). U. S. 2,070,322, Feb. 9, 1937 (May 25, 1935).

Beet knife sharpening machine. S. T. FERRAS AND N. C. BYR (Henry Dieston & Sons, Inc.). U. S. 2,069,540, Jan. 26, 1937 (Feb. 14, 1934).

Composite grinding wheel and method of making. BAILEY SANFORD (Norton Co.). U. S. 2,069,116, Jan. 26, 1937 (Feb. 14, 1935). An abrasive wheel comprises a substantially uniform thickness which has its two rectangular portions united by compression while plastic and set by heat as an inflexible integral mass, wherein the flange sheets are arranged within the planes formed by the sides of the annulus and radially strengthen the wheel.

Device to prevent buckling of sheet metal during grinding or polishing. S. O. HANNA. U. S. 2,071,033, Feb. 16, 1937 (Aug. 15, 1936). U. S. 2,071,034, Feb. 16, 1937 (Aug. 15, 1936).

Drill-grinding appliance. G. D. HARRIS. U. S. 2,034,915, Jan. 26, 1937 (July 21, 1932).

Gear-lapping machine. E. W. MILLER (Fellows Gear Shaper Co.). U. S. 2,069,324, Feb. 2, 1937 (Feb. 2, 1934).

Grinder. J. J. WAUGH (Globe Slicing Machine Co., Inc.). U. S. 2,069,431, Feb. 2, 1937 (Feb. 17, 1932). The combination of a slicing machine having a rotary knife with a grinder support pivoted at a point spaced from the knife, a pair of grinders supported thereby and movable toward and away from the face of the knife.

Grinding or abrading machines. NORTON CO. Brit. 456,516, Jan. 26, 1937 (Sept. 19, 1934). F. WATERS A.-G. Brit. 459,551, Jan. 26, 1937 (June 17, 1935).

Grinding device. H. J. PARAZZOLI. U. S. 2,069,370, Feb. 9, 1937 (Oct. 25, 1934). A grinding device includes a pair of members mounted in spaced relation and having drum surfaces.

Grinding machine. W. G. BALDENHOFER (Thompson Grinder Co.). U. S. 2,068,520, Jan. 19, 1937 (March 24, 1932).

Grinding machines for hard materials. SWEN SFACHERS, LTD. Brit. 458,425, Dec. 31, 1936 (March 24, 1935).

Grinding wheel. NORTON GRINDING WHEEL CO., LTD. Brit. 459,470, Jan. 26, 1937 (April 18, 1935).

Grinding wheel and method of balancing. C. J. HUDSON (Norton Co.). U. S. 2,070,360, Feb. 9, 1937 (Dec. 9, 1930). The method of balancing an abrasive wheel consists in introducing into the pores of the wheel, on the light side of its axis, a sufficient quantity of pulverized mineral material in a vehicle of water with a wetting agent to make the weight of the light side substantially equal to the weight of the heavy side, the presence of such material not altering the grinding properties of the wheel. Honing tool. E. W. CONNOR, G. M. CALVERT, and ALBERT BLANDMANN (Micromatic Home Corp.). U. S. 2,070,365, Feb. 16, 1937 (July 15, 1937).











for a definite time and placed in contact with the film for various times; the densities were measured. This gives the "phosphorescence decay." The yield and decay curves are of the same shape as those found by Swindells for  $\text{CaWO}_4$ . It is concluded from comparison with previous work that there will be correlations between solvation and phosphorescence and the decay of these effects. See "Solvation," *Ceram. Abs.*, 14 [10] 246 (1935).

Plan method for viscosity measurements of glass. WILLI M. CORN. *Glass Ind.*, 17 [11] 375-76 (1936). An improved Stokes' law for a liquid in a crucible is as follows:

$$\eta = \frac{2R^2(\rho_A - \rho_B)(1 - \frac{R}{2a})}{9a(1 + \frac{3.2}{R})}$$

in which  $\eta$  = the viscosity,  $g$  = the gravity,  $R$  = the radius of the sphere,  $r$  = the radius of the container with the melt,  $a$  and  $b$  = the densities of the sphere and melt,  $\rho$  = the rate of fall of the sphere, and  $h$  = the height through which the sphere falls. A crucible, 6 in. in height and 2 in. in diameter, of a highly refractory material such as sillimanite, is placed in a furnace. The glass is melted in this crucible until free of bubbles, and then cooled to the temperature when it is in a semiliquid state. After the melt has reached a temperature equilibrium, measured by means of one or two thermocouples, a sphere of 80% platinum-20% rhodium of about 10 mm. diameter is dropped into the melt. After a certain length of time, e.g., 60 min., a second sphere and after 120 min., a third sphere are dropped into the melt. About 120 min. after the dropping of the third sphere, the crucible is quickly removed from the furnace and cooled in SiO<sub>2</sub>-Oxide powder. On cooling to room temperature, the crucible is split along its axis and the distance traveled by the spheres is measured. These data give the rate of fall,  $\rho$ , in the middle part of the crucible. Inserting the correct values and constants in the formula gives the viscosity of the glass at this particular temperature. Viscosity values obtained were reproducible, the maximum deviation being +3%. Application of the method to tasks is discussed. See *Ceram. Abs.*, 14 [8] 196 (1935).

Process of dissolving grog particles in soda-lime glass. N. S. MANTLOVA. *Keram. & Staklo*, 12 [10] 31-34 (1936).—Grog stones dissolve very well in glass, under a series of transformations, beginning with a whitish-yellow grain of grog and finally changing into a small transparent and drop-like formation called "eye" or "knot." This process depends on a series of causes, such as (1) time the grog is in the melt, (2) rate of diffusion between the materials of the stone and those of the glass, (3) alkalinity of glass, (4) temperature, (5) viscosity, etc. The grog stone begins to dissolve in its periphery with a dissolving of sunlike and concentration of alumina. Corundum changes into nepheline or carnegite and the latter gradually dissolves in the glass. Nepheline often disappears without leaving any traces, while carnegite leaves always tiny crystals of cristobalite. Details are given. Illustrated. M.V.C.

Production of opaque glasses dispersing light. S. M.

BERNEHVERKKE. *Keram. & Staklo*, 12 [11] 7-10 (1936).—The glass used is classified as a special milk glass called "opaque opal" because of its appearance, optical properties, and character of opacification. The minimal undispersed permeability of this glass is obtained by a high alumina content. Lowering of the Al<sub>2</sub>O<sub>3</sub> content produced transparent glasses. CaO and B<sub>2</sub>O<sub>3</sub> greatly lower the effect of opacification and increase permeability to light of the glass. Increase of the K<sub>2</sub>O for Na<sub>2</sub>O increases transparency and the opacification of glass. Opacification required was obtained by introducing CaO as dehydrated gypsum. Replacement of gypsum by other calcium salts did not produce the necessary opacity. The introduction of MgO, even in small amounts, destroyed the effect of opacification, making the glass transparent. Small quantities of arsenic promote the burning of the opacifiers. Replacement of lead oxide by barium and zinc oxide lowers the effect of opacification. The glass must be annealed between 380 and 400°C. At an annealing temperature of 440°, opacifiers burn out, and at 450 or 470° glass becomes almost transparent with a weak blue color tone. This is probably due to a decrease in size of particles of the opacifier. The character of firing must be reducing, as with an oxidizing flame, opacifiers burn out more rapidly. The addition of color lowers the effect of opacification. M.V.C.

Proper construction of burners for glass furnaces. M. D. TAMARIN AND A. S. RUHA. *Keram. & Staklo*, 12 [10] 16-18 (1936).—The correct position of burners in glass furnaces is discussed in detail. Illustrated. M.V.C.

Reaction of glass upon orthotoluidine. D. W. HORNE. *Amer. Jour. Pharm.*, 106, 324-25 (1936); *Analyst*, 61, 722 (1936).—Orthotoluidine in contact with glass produces a yellow color indistinguishable from that given when  $\alpha$ -toluidine and "active chlorine" interact. The color is more pronounced with long standing, heating, or autoclaving. I.H.S.

Relations between drawing temperature of glass, flow index, and the specific molting capacity of tanks. K. MARZONA. *Glastech. Ber.*, 12, 381-85 (1934); *Chem. Abstr.*, 29 [3] 897 (1935).—The following formula is developed:  $L/F = 1/Mg(1 - F/P)(1 - \alpha)$ , where  $L/F$  represents the specific molting capacity in kg./sq. m./hr.;  $L$  is the hourly capacity in kg./hr.;  $m$  is flow index (which shows how much more glass flows from the melting to the working end than is worked out);  $\alpha$  is the specific heat of the glass in kg.-cal./kg. (its value is 0.28 if the same temperature is assumed for melting and drawing);  $g$  is the hourly heat loss in kg.-cal./sq. m. of the crown and the side walls of the unheated parts related to 1 sq. m. of unheated hearth surface (this value can be taken as 10,000 kg.-cal./sq. m./hr.);  $t_1$  is the melting temperature (usually 1400°);  $t_2$  is the working temperature of the glass;  $F$  is the total hearth surface in sq. m.; and  $P$  is the heated hearth surface (melting surface) in sq. m.

Resistance of glass plates to wind pressure. N. MARSDEN. *Jour. Japan. Ceram. Assn.*, 41, 188-90 (1933); *Jour. Soc. Glass Tech.*, 18, 212A (1934).—For the same thickness of plate the resisting power is approximately inversely proportional to the area. The following average bending strengths are given: 2-mm. plates, 725 kg./sq.

cm.; 3-mm. plates, 562 kg./sq. cm.; 5-mm. plates, 467 kg./sq. cm.; and 6-mm. plates, 425 kg./sq. cm. In this plates fractures extend over the whole sheet, but for thick, small plates fractures are generally confined to the center.

Rate of chemistry in polishing processes. J. V. GOSNARD-SCHNEIDER. *Sobolod. Bolenslavskoye i Nishki*, No. 2, pp. 22-23 (1935); *Chem. Abstr.*, 29, 8172 (1935).—A theory is given of polishing based on the chemical nature of the substances employed. The greatest thickness ( $100 \times 10^{-6}$  cm.) of a polished layer of glass is obtained by polishing with acidulated water of  $\text{pH}$  3.8, and the smallest ( $4 \times 10^{-6}$  cm.) is obtained with transformer oil. Some salts in a 1% solution exercise a specific influence;  $\text{NH}_4\text{F}$  retards glass polishing.  $\text{H}_2\text{O}$  acts hydrolytically upon the polished surface of the glass (as well as upon basal and feldspar), covering it with a protective colloidal film of silicic acid 14 to 70 Å thick.  $\text{Fe}_2\text{O}_3$  calcined at 750° at the highest dispersion is adsorbed simultaneously by the SiO<sub>2</sub> film and by the surface of the rosin polishing composition. In polishing metals a protecting film of oxides is formed. The polishing of a steel sample either in a H atmosphere or by connecting it with the cathode is slower than in a mixture of  $\text{H}_2$  with  $\text{H}_2\text{S}$  in the air, or by connecting it with the anode. The polishing powder, the best being  $\text{Cr}_2\text{O}_3$  from  $\text{K}_2\text{Cr}_2\text{O}_7$  and  $\text{S}$ , absorbs the fat parts of the stearic acid molecule used as a metal lubricant and distributed on it in unimolecular layers. The acid parts of the molecules of this acid are combined with the surface oxides of the metal. The connection established, therefore, between the metal and the polishing material is broken during the movement of the metal and then reestablished.

Safety glass and its application to building. W. KAMMERBRECHT. N. Y. Times, p. 8XX (Jan. 10, 1937).—Ordinary glass is "caulked" by being heat-sealed to about 1150°F and suddenly chilled by a blast of cold air. After this treatment, the glass can not be drilled or otherwise worked without disrupting into little blunt-edged cubes which, however, remain in one plane and tend to interlock. A light sharp blow from a hammer will disrupt this new glass, while a half-pound steel ball dropped from a height of 10 ft. bounces off without breaking the plate. The glass is 4½ times as strong as ordinary glass and will bend a hair.

Separation by decantation of liquid layers in molten boro-silicate-earth glasses. M. A. FOX. *Compt. Rend.*, 202 [19] 1582-84 (1936).—Most of the boric glasses, especially those of the lime, strontium, and barium type, show two liquid layers between certain limits of composition and temperature. In all cases, the upper layer presents in cooling a vitreous and opalescent aspect. The conditions for this separation as functions of time concentration were investigated for a two-oxide glass by means of electric conductivity measurements. The results are shown in curves from which it can be concluded that, for a given temperature, the ratio of the densities of the two layers is constant in the alkali-silicate glasses.

Two-layer thermal insulation of tank furnaces. S. S. BERMAN. *Keram. & Staklo*, 12 [8-9] 21-30 (1936).—Presents computations for two-layer thermal insulation of tank furnaces. M.V.C.

Types of furnaces used for sheet glass manufacture.

P. S. ENGLISH. *Keram. & Staklo*, 12 [8-9] 17-20 (1936).—The Gobbe and Berman furnaces are dealt with. M.V.C.

Using Fourcault machines in the manufacture of colored signal glasses. V. G. SEMENOV. *Keram. & Staklo*, 12 [11] 10-11 (1936).—S. describes experiments in using Fourcault machines for the production of colored signal glasses. The results are tabulated. M.V.C.

Variation of the refractive index of unannealed glass as a function of time. NIVYA KLIM. *Compt. Rend.*, 201, 329-31 (1935).—Further results of an investigation (*Ceram. Abs.*, 14 [11] 275 (1935)) are given, and an equation is derived to determine the variation of the index with temperature. M.H.

Viscosity of glass. F. GLARUS, L. DUBOIS, G. HENRY, SCOUR, and J. DEBET. *Bull. Soc. Chim. Belg.*, 45 [4] 131-70; [5] 379-437 (1936).—An exhaustive survey undertaken by the (Belgian) National Fund for Scientific Research discusses the characteristics and properties of the viscous and vitreous states in glass in the light of recent investigations and gives the numerical values obtained in the results for the viscosity of different types of glass, the effects of thermal treatment, and the change of viscosity as a function of temperature. Instruments and testing methods are described in detail. 78 references. M.H.

#### BOOK AND BULLETIN

Dielectric losses in glasses at high frequency. E. A. KRAVAK. State Bureau Publishing House, Leningrad, 1932. 6 pp., 2 figs. Reviewed in *Jour. Soc. Glass Tech.*, 18, 228-29 (1934).—Dielectric losses at a frequency of  $2 \times 10^4$  oscillations per second were determined by making a test tube of the glass, filling it with mercury, and placing it in a Dewar's vessel with mercury. A thermometer was immersed in the test tube. An electrode was introduced in the mercury in the Dewar's container, and other into the test tube. Curves representing the rise in temperature as a function of time determined the amount of heat developed in the calorimeter in consequence of dielectric losses for a definite unit of time. Results for several glasses are given.

General Technology of Glass Manufacture. M. A. BERNARD. Glastech. Ber., 1936. 201 pp., 88 illustrations. Reviewed in *Keram. & Staklo*, 12 [11] 58 (1936).—H. describes, in a clear and simple way, the theoretical and technical sides of the technology of glass for workmen and minor officials of glassworks. M.V.C.

#### PATENTS

Apparatus for: Caschardening glass. R. S. HENRY (Libbey-Owens-Ford Glass Co.). U. S. 2,068,746, Jan. 26, 1937 (May 6, 1935).

Making curved safety glass. E. H. HAUX (Duplate Corp.). U. S. 2,068,104, Jan. 19, 1937 (Feb. 23, 1935). Tempering glass sheets. PLEIKENTON BROS., LTD., AND L. J. B. FORBES. Brit. 457,475, Dec. 9, 1936 (May 24, 1935).

Tempering glass sheets. AMERICAN SECURITY CO. Brit. 450,870, Jan. 27, 1937 (July 16, 1934). Testing electric-lamp bulbs, etc., for leaks. BATTISTE TROUSSEAU-HOCHSTETTER CO., LTD. Brit. 457,954, Dec. 23, 1936 (Dec. 12, 1934).

Boronate glass containing cerium. H. P. HOON (Corning Glass Works). U. S. 2,068,801, Jan. 20, 1937 (July 30, 1935). A boronate glass containing a substantial amount of cerium also contains not more than 10% of alkali oxide and is free of the presence of an oxide of the group consisting of barium oxide and zinc oxide.

Coloring agents for glass batches and method of employing. R. L. DU PONT DE NEMOURS & CO. Brit. 459,880, Jan. 27, 1937 (July 18, 1934).

Composition for etching and etching transfers. NANCY CARON-KENNEDY. U. S. 2,067,925, Jan. 19, 1937 (March 7, 1934). An etching composition for etching glass comprises an acid fluoride disseminated through a carrier medium consisting of cornstarch, black treacle, sugar syrup, gum arabic, gum tragacanth, carbon black, finely ground magnesium carbonate, and a glycerine containing plasticizer, the proportions being such as to provide a composition sufficiently elastic and firm to permit printing or transfer to glass without blurring during the printing or for a sufficient period to permit etching.

Cooling devices for tempering glass. HENRIOD-BATTISTE GLASWIKER EICHENROUX & CHU, GRS. Brit. 458,790, Jan. 7, 1937 (March 9, 1935).

Cover glass. S. L. LAMAY (Corning Glass Works). U. S. 2,068,806, Jan. 20, 1937 (Feb. 4, 1935).

Devices for molding glass under pressure. W. RINTHAMMER. Brit. 458,556, Jan. 7, 1937 (May 1, 1935). Furnace. L. D. SOUVERE (Owens-Illinois Glass Co.). U. S. 2,069,542, Feb. 2, 1937 (Feb. 23, 1935).

Glassblowing machines. E. G. BENDON (Lynch Corp.). U. S. 2,069,130, Jan. 20, 1937 (June 4, 1917; July 16, 1927).

Glass building block. D. E. GRAY (Corning Glass Works). U. S. 2,068,798, Jan. 20, 1937 (May 21, 1934).

Glassmaking apparatus and method. VERNON McHILLAND (Hartford-Empire Co.). U. S. 2,068,925, Jan. 20, 1937 (June 13, 1934).

Glass-to-metal seal. R. BRUGER AND A. W. HULL (General Electric Co.). U. S. 2,071,190, Feb. 16, 1937 (Jan. 4, 1934).

Glass mold. ANTHONY ROSA. U. S. 2,070,493, Feb. 9, 1937 (April 17, 1935). A portable glass mold for the blowing of glassware is described.

Glass tank feeding shield. F. G. SCHWALBE (Toledo Engineering Co., Inc.). U. S. 2,068,515, Jan. 19, 1937 (April 16, 1935).

Laminated glass and process of making. J. H. SHWARTZ (Duplate Corp.). U. S. 2,068,082, Jan. 19, 1937 (June 8, 1935).

Machine for forming glassware. T. F. FRANKLIN. Brit. 459,269, Jan. 7, 1937 (March 23, 1935).

Machine for forming hollow glass containers. L. D. SOUVERE (Owens-Illinois Glass Co.). U. S. 2,069,541, Feb. 2, 1937 (Aug. 1, 1934).

Manufacture of glass wool. D. C. SIMPSON (Owens-Illinois Glass Co.). U. S. 2,068,902, Jan. 19, 1937 (Nov. 23, 1932; renewed March 29, 1930).

Manufacture of laminated glass. A. KAMPER. Brit. 458,008, Jan. 7, 1937 (Oct. 1, 1934).

Manufacture of laminated glass. C. S. SHONMANN (American Window Glass Co.). U. S. 2,069,426, Feb. 2, 1937 (June 8, 1935). In the manufacture of laminated

glass the steps consist in forming a film of a solution of a polymerized acrylic acid ester on a glass sheet, thereafter drying the film on the glass sheet by heat, forming a film of dibutyl phthalate on the coating on the glass sheet, forming a sandwich of the coated glass sheet with a similarly coated glass sheet with the strengthening material therebetween, and thereafter, without the application of heat, subjecting the sandwich to pressure and permitting it to cool down under pressure.

Manufacture of unstable glasses. GENERAL ELECTRIC CO., LTD., AND J. H. PATTERSON. Brit. 458,042, Dec. 23, 1936 (July 18, 1935).

Means for and method of applying color to molded glass articles. A. G. EDE. U. S. 2,067,549, Jan. 19, 1937 (Feb. 23, 1935). (1) The method of coloring a molded glass article during the period of its formation consists in directing a fusible coloring pigment against the parts to be colored following removal of the article from the mold and at a location in its course of travel at which its initial molding heat will have decreased to the fusing temperature of the pigment. (2) The combination with a machine for molding glass articles, a lever for annealing the articles, a pigment-applying machine, including a stencil disposed intermediate the molding machine and the lever, means for conveying the articles from the molding machine to the pigment-applying machine and from the pigment-applying machine to the lever, and means operating on the articles between the molding machine and the pigment-applying machine for modifying the initial molding heat of the article, the pigment-applying machine being movably mounted relative to the molding machine and the lever, whereby the pigment-applying machine may be positioned so that the initial molding heat retained in the articles at the time the articles are submitted to the action of the pigment-applying machine will be suitable to cause the pigment contacting with the articles to be fused therein within the areas defined by the stencil.

Method and apparatus for annealing glassware. D. G. MISKELL (Hartford-Empire Co.). U. S. 2,068,923, Jan. 20, 1937 (Nov. 8, 1935).

Method and apparatus for manufacturing and fabricating glass wool. D. C. SIMPSON (Owens-Illinois Glass Co.). U. S. 2,068,902, Jan. 19, 1937 (Oct. 27, 1935; renewed March 29, 1930).

Method and apparatus for the manufacture of hollow glass articles. E. G. BENDON (Lynch Corp.). U. S. 2,071,295, Feb. 16, 1937 (Dec. 28, 1929).

Method and apparatus for tempering glass. P. A. CLEMO (American Security Co.). Brit. 457,488, Dec. 9, 1936 (May 30, 1935).

Method of:

Feeding glass and an apparatus therefor. S. G. STUCKEY (Owens-Illinois Glass Co.). U. S. 2,069,982, Feb. 9, 1937 (April 7, 1934).

Forming hollow glassware. HARTFORD-EMPIRE CO. Brit. 458,231, Dec. 31, 1936 (May 24, 1935).

Forming glass articles. H. STERNER. Brit. 458,115, Dec. 23, 1936 (April 16, 1935).

Producing decorative designs on glass. J. C. CORAN AND LONDON SAND BLAST DISCOGNITIVE GLASSWORKS, LTD. Brit. 457,953, Dec. 23, 1936 (Nov. 27, 1935).

Producing laminated glass. A. KAMPER. Brit. 457,345, Dec. 9, 1936 (June 9, 1934).

Mold for the manufacture of glass vessels. VERKEHRENS GOMLETTRENS I TERNERSEN CO. ANON. Brit. 458,590, Jan. 7, 1937 (Feb. 2, 1935).

Plastic for laminated safety glass. G. B. WATKINS AND J. D. RYAN (Libbey-Owens-Ford Glass Co.). U. S. 2,068,782, Jan. 20, 1937 (June 28, 1934).

Plate glass surfacing car. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,068,056, Jan. 19, 1937 (April 30, 1935).

Process for the manufacture of refractory products. V. M. GOLDSCHMIDT. Brit. 458,407, Dec. 31, 1936 (Jan. 14, 1935).

Production of glass articles. WURTTESBERGER METALLWARENFABRIK AND H. DEBACI. Brit. 459,201, Jan. 13, 1937 (Sept. 7, 1935).

Production of glass bottles, particularly glass shells, with an indrawn rim. WURTTESBERGER METALLWAREN-

Berlin's use of stoneware. FELIX SONDER. *Clay Prod. Jour. Australia*, 4 [3] 17 (1937).—Berlin sewerage is constructed only from stoneware of the first quality. During the building of an underground railway in Berlin, stoneware pipes laid down 45 years previously had to be excavated. They were all in first class condition. See *Ceram. Abs.*, 14 [7] 164 (1935).

Brick road paving. O. N. HODSON. *Chem. & Ind.*, 55 [24] 472-74 (1936).—The history of brick roads is briefly outlined. The practice of laying a brick pavement in the U. S. is treated under the following points: (1) drainage, (2) curbs, (3) natural bases, (4) artificial bases, (5) bedding course, (6) brick, and (7) asphalt fill. The methods of constructing and testing experimental brick roads in England are described.

Elimination of efflorescences in tile and brick. M. BERNON. *Congr. Chim. Ind.*, 14th Congress, Paris, 1934. 2 pp.; *Chem. Abs.*, 29, 6379 (1935).—The formation of CaSO<sub>4</sub> efflorescences can be prevented by adding 2 to 6 g. of precipitated BaCO<sub>3</sub> per ton of clay.

Pipes for sewerage purposes. ANON. *Clay Prod. Jour.*

FABRIK AND H. DEBACI. Brit. 459,200, Jan. 13, 1937 (Sept. 7, 1935).

Refractory glasses. GENERAL ELECTRIC CO., LTD., AND J. H. PATTERSON. Brit. 458,881, Jan. 13, 1937 (Nov. 11, 1935). Brit. 459,055, Jan. 13, 1937 (Nov. 26, 1935).

Regenerator tank and method of operating. VERNON McHILLAND (Hartford-Empire Co.). U. S. 2,068,920, Jan. 20, 1937 (Dec. 2, 1935).

Safety glass. CAMBIE & CARBON CHEMICALS CORP. Brit. 459,290, Feb. 3, 1937 (Aug. 20, 1934).

Tempering glass. E. M. GUYER (Corning Glass Works). U. S. 2,068,709, Jan. 20, 1937 (Feb. 23, 1935). The method of tempering a glass body includes heating it by cradling it in a sand bath within it and cooling its surface while it is being so heated.

Tempering of plates of glass. PLEIKENTON BROS., LTD., AND L. J. B. FORBES. Brit. 457,587, Dec. 9, 1936 (May 31, 1935).

#### Structural Clay Products

Australia, 4 [3] 6 (1937).—The Inst. of Engineers of Australia has appointed a committee of enquiry into the merits of different makes of pipes for sewerage purposes.

Stoneware's worst obstacle. ANON. *Clay Prod. Jour. Australia*, 4 [3] 8 (1937).—The greatest obstacle encountered by protagonists for stoneware pipes is the highly trained young university graduate. Heregards a stoneware pipe as just a stoneware pipe; there is nothing to be learned from it. A concrete pipe, however, has proportions of sand and cement and interstices; small test blocks can be made, it can be designed and constructed, and its breaking load can be predicted. Thus it is an object of interest and study.

Super-ceramic building members. F. O. ANDERSON. *Amer. Ceram. Soc.*, 20 [3] 77-79 (1937).

Manufacture of brick. O. R. ROUSSE. Brit. 457,884, Dec. 23, 1936 (June 4, 1935).

#### Refractories

Ceramics in India: Potteries and fire brick. ENTORIAL. *Indian Eng. (Special Supp.)*, pp. 41-42 (Dec. 1936).—The gradual expansion of the Rangoon Pottery Works and the Heland Firebrick and Pottery Co., Ltd., and the development *pari passu* of the Indian ceramic industry are reviewed. These two works have practically rendered the Indian iron and steel industry independent of imported fire brick.

Cristobalite. D. S. BALKANYAN AND N. G. KAZAKOVA. *Tran. Inst. Petrogr. Acad. Sci. U.R.S.S.*, 6, 302-08 (1934). *Trans. Soc. Glass Tech.*, 20 (77) 6A (1936).—Cristobalite from the bones of siliceous brick from an open-hearth furnace was examined. A stable form was found in that end of the brick which had been in direct contact with the furnace gases at temperatures higher than 1470° and a metastable form due to the process of firing in the manufacture of siliceous brick at temperatures lower than 1470°.

Effect of manufacturing factors on properties of grit brick with a high grog content. R. MAKHL. *Keram. & Staklo*, 12 [8-9] 26-32 (1936).—The nature of clay used for the production of these bricks is of the highest importance. Clays which sinter well at low temperatures, such as Chasov-Yar clays, produce excellent grit brick. Clays which do not sinter satisfactorily at low temperatures, such as the Latsinskii type of clays, are unsatisfactory. The nature of grog and its granulometric composition are also important. Clays sintering well at low temperature yield high-grade grog. Samples containing from



15 to 20% of the so-called grog dust, i.e., grog granules of less than 0.15 mm., were of high grade, while those without grog dust were of low mechanical strength.

**Electrodials.** T. S. SHELTON, L. V. DUBROVSKAYA, and S. LAURITSCHENKO. *Trab-Sov.* 27 (1936) 8 pp. (1936); reviewed in *Refract. Silikoliterat.*, 3, 3478 (1936).—The new silica brick with 43 charges in the crown of an electric steel furnace. The resistance to firing of silica brick is affected by the properties of the raw materials and the amount of salt of lime added. The firing point of pure quartzite is 1700°, and that of a silica brick with 2% lime is 1720 to 1730°. Obviously, a low lime addition is desirable. Tests show, however, that (under similar conditions) the brick with less than 2% lime had a drilling and cracks because the thickness of the lime film was inadequate. To obtain a sufficiently thick lime film with less than 2% lime, the total surface of the grains in the mix was lowered by using coarser grains (corrections for granulometric curves are given). In the new silica brick, the moisture content is 5.6 to 6.3% (old brick 6 to 6.8%); the lime content is 1.5%, and much better properties are obtained.

**Faking of continuous vertical rebars.** A. T. GAZAR and F. H. CLAWES. *Refract. Materials Joint Sub-Committee, Inst. Gas Engrs.*, 24th Rept., No. 78, pp. 70-92 (1935); *Chem. Abs.*, 29, 6380 (1935).

**High-temperature refractories.** Z. UENO. *Jour. Inst. Japan*, 13, 91-93 (1934); *Brit. Chem. Abs.*, 3, 1471 (1934).—The manufacture and properties of carbide electrocatalytic alumina, e.g., 70% refractories, which are highly resistant to corrosion by slag, glass, cement, and metals. The main properties of carbide black (the electrocatalytic product) and white (made by bonding the pulverized cast material) are, respectively, as follows: refractories, cone 38 (approximately 1800°), cone 38 (1760°); refractories under heat (2 kg./sq. cm.), > 1740°; 1400 to 1600°; linear thermal expansion at 1000°, 0.53% for both; thermal conductivity (kg.-cal./sq. in./in./°C. for 1-cm. thickness), 3.29 and 1.67 at 200°, 2.95 and 1.40 at 1200°; crushing strength 1000 to 1200, 350 to 750 kg./sq. cm.; porosity, 1.10 to 20%; density 3.3 to 3.4, 3.2 to 3.3; hardness (Mohr) 42 (Martini's scale).

**Hot patching of gas retorts.** II. Experiments on the use of dry clays containing sodium and aluminum. F. H. CLAWES, H. BOON, and A. T. GAZAR. *Refract. Materials Joint Sub-Committee, Inst. Gas Engrs.*, 24th Rept., No. 78, pp. 7-19 (1935); *Chem. Abs.*, 29, 6379 (1935).

**Insulating and high-temperature refractories.** ANON. *Met. Progress*, 26 (4) 77-80 (Oct., 1934); abstracted in *Brit. Non-Ferrous Metals Research Assn.*, No. 70, p. 25 (1934).—Progress in the production of refractories derived from clays and rocks, e.g., insulating refractories, high-temperature refractories, refractory cements, and ramming mixes, is discussed.

**Joining cements.** I. Preliminary investigations. A. T. GAZAR and H. N. ROY. *Refract. Materials Joint Sub-Committee, Inst. Gas Engrs.*, 24th Rept., No. 78, pp. 57-67 (1935); *Chem. Abs.*, 29, 6389 (1935).—The literature is reviewed. Physical and refractory properties of eight

fireclay and four silica cements are given. The texture is related to the drying and firing shrinkages, tensile strength, and adhesion. There is some connection between the texture of a cement and its behavior in the under-slag test. II. Experiments on silica cements. F. H. CLAWES, H. BOON, and A. T. GAZAR. *Refract. Materials Joint Sub-Committee, Inst. Gas Engrs.*, 24th Rept., No. 78, pp. 67-78 (1935); *Chem. Abs.*, 29, 6380 (1935).—Refractories under light load for small contents of lime in lime-quartz mixtures is severely affected by the proportion of lime; slight contamination with other oxides modifies this conclusion. Gansler-line cements had little adherence to the brick. Other results are more preliminary in nature.

**Methods of determining permeability of refractory materials.** T. R. LYMAN and W. J. RANS. *Refract. Materials Joint Sub-Committee, Inst. Gas Engrs.*, 24th Rept., No. 78, pp. 31-34 (1935); *Chem. Abs.*, 29, 6380 (1935).

**Methods of avoiding cracks and bad structure in the production of refractories for blast furnaces.** V. SPARKS. *Openwork*, 2 (10) 18-23 (1934); *Chem. Abs.*, 29, 151 6239 (1935).—The following granulometric composition gave a good structure and improved the mechanical strength, water absorption, and volume porosity: grains of 0.6 mm. 60%, of 1 mm. 22 to 25%, and of 2 mm. 10 to 15%. An increased moisture content (to 16 to 17%) gave better results in pressing. See *Ceram. Abs.*, 14 (8) 180 (1935).

**Methods of high-temperature insulation.** T. BARRETT. *Steam Engr.*, 6, 25 (1935); *Trans. Ceram. Soc.*, 35 (11) 98A (1935).—The fundamental principles of insulation of furnace walls, arches, and roofs, steel-reheating furnaces, glass tanks, and open-hearth furnaces are discussed.

**Properties and uses of mullite refractories.** M. L. PERRO. *Ind. Heating*, 4 (1) 57-62 (1937).—Properties required of high-temperature refractories are discussed. A refractory for temperatures of 3000° and higher, mullite, consisting of calcined sillimanite minerals (kyanite, andalusite, and sillimanite) is described. Fields of application as lining materials, in places where flames impinge, in high-frequency furnaces, and, in general, where refractories are subject to excessive spalling conditions and heavy loads at high temperatures are mentioned.

**Refractories.** ANON. *Trade & Eng.*, 40 (875) xviii (1937).—A review of commercial practice and research during 1936 is given. Refractories in the British Isles are still sold more on "reputation" than on tests, but buyers are increasingly co-operating with manufacturers. No great changes in methods of manufacture were made in 1936, but the general increasing mechanization is noticeable. Super-refractories are slowly growing in popularity, and much interest has been shown in brick made of celadon (a barium amorphite) and in highly porous brick for thermal insulation. Plastic refractories or refractory cements are being increasingly used. A "standard ganister mixture" is now obtainable. Research is chiefly confined to changes in physical properties on heating. A serious effort is being made to place the financing of research on a sound foundation.

**Refractories for enameling muffle furnaces.** J. WALKER. *Foundry Trade Jour.*, 54 (1934) 265-68, 270 (1935).

**Refractories for enameling muffle furnaces.** J. WALKER. *Foundry Trade Jour.*, 54 (1934) 265-68, 270 (1935).—The general requirements for refractories in

struction comprises an outer wall of brick and an inner wall of interlocked refractory tile constructed and arranged for relative movement and to oppose the transfer of heat, a course of header brick laid in the outer wall and loose in the inner wall to oppose heat transfer, there being spaces underlying the header brick to permit movement of the inner wall and to support the upper portions of the latter when portions of the inner wall rest on the upper faces of the header brick, and hinged through-bolts connecting the walls substantially as described.

**Furnace for heating materials under sustained pressure.** P. R. CHURCH and H. C. RAYNAU. U. S. 2,070,983, Feb. 16, 1937 (April 2, 1936).

**Furnace-wall construction.** MARTIN FREICH (Foster Wheeler Corp.). U. S. 2,070,267, Feb. 16, 1937 (April 24, 1937).

**High-pressure nonplastic refractory and method of making.** R. P. HEUER (General Refractories Co.). U. S. 2,068,411, Jan. 19, 1937 (Jan. 9, 1934). The method of making a refractory of high density from anhydrous nonplastic material and a bonding substance using anhydrous nonplastic particles of relatively larger and smaller grain sizes consists in mixing larger anhydrous nonplastic particles retained on a 30-mesh per linear inch screen with smaller anhydrous nonplastic particles and a bonding substance while employing not more than a relatively small proportion of intermediate anhydrous nonplastic particles, in molding the mix in moist condition into a refractory shape, in drying the refractory shape, and in subjecting the dried unfired refractory shape to firing temperature in a furnace structure during use.

**Sectionally supported wall.** H. A. MANNHARDT (American Arch Co., Inc.). U. S. 2,068,803, Jan. 26, 1937 (Aug. 1, 1937).

**Spalling resistant refractory brick.** G. M. CARRER, J. W. CRAIG, P. E. LATHE, and A. C. HALPERN. U. S. 2,068,541, Jan. 26, 1937 (July 15, 1931). A spalling-resistant, refractory, and chemically and physically containing 16 to 20% of chrome iron ore and 50 to 85% of a dead-burned magnesian clinker which contains 10 to 25% of lime, and consisting of coarse and fine particles of which the chrome iron ore is the coarse constituent.

**Production of engobe tile.** H. HENDON. *Brit. Dent. J.*, 45 (1937) 611-16 (1937).

**Various types of kilns used in this industry are discussed with special reference to intermittent kilns. A round downdraft kiln and a rectangular downdraft kiln are described. See *Ceram. Abs.*, 16 (3) 96 (1937). R.A.H.**

**Method for determining acid-stable natural rocks, ceramic ware, and bodies for chemical apparatus.** L. V. MURAVLEV. *Trudy Vsesoyuz. Mendeliev. Seda. VI Sess.*, 2 (Part 1), 213-14 (1935); abstracted in *Chem. Zvest.*, 1936, II, 2972-73. The ground and sifted material was washed with distilled water and dried. 1 kg. of the sample is treated with 25 cc. c.p. H<sub>2</sub>SO<sub>4</sub> boiled, cooled, diluted with distilled water, and filtered. The residue is washed with hot water and treated with 20 cc. hot water and 5 cc. NaCl solution (5%); Cl is washed off. The dried and obtained residue yields acid stability.

**Apparatus for applying glaze, etc., to tile.** W. BOULTON, LTD., and H. H. HALL. *Brit. Dent. J.*, 45 (1937) 611-16 (1937).

**Insulating material having a high dielectric constant and a process of producing.** WERNER SORCK and ALBERT UNGERWITZ. U. S. 2,069,905, Feb. 9, 1937 (Dec. 27, 1935).

**Insulating material having a high dielectric constant and a process of producing.** WERNER SORCK and ALBERT UNGERWITZ. U. S. 2,069,905, Feb. 9, 1937 (Dec. 27, 1935).

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clude (1) high refractoriness, (2) high strength, hot or cold, (3) volume stability at high temperatures, (4) resistance to slag attack, (5) resistance to rapid temperature changes and other thermal stresses, (6) low or high heat capacity, (7) low or high thermal conductivity, and (8) low or high electrical conductivity. In general, commercial refractories are compromises which meet a group of contradictory requirements fairly well. The ideal refractory for enamel muffle is analyzed from the standpoint of the above requirements, and the differences in coal, gas, and oil-fired and electrically heated furnaces are pointed out. Discussion. WITTENBERG *et al.*, *Ind.*, (1932) 372, 374.

**Refractories in the foundry and furnace.** W. HAMILTON. *Foundry Trade Jour.*, 54 (1935) 101 (1935).—Results obtained from practical experience in the use of refractory materials in both foundry and furnace are given. In connection with molten sand, the refractory manufacturer has given the foundryman valuable assistance in finding a suitable sand and in blending, grading, and bonding. Monolithic cupola linings have been considerable progress and may be universally adopted in the future. The same is true of the steel converter, either Stock or Tropman. The high-alumina refractory brick is being successfully used in foundry furnaces. A brick composed of chrome and magnesian of definite proportions to counteract some of the failings of the magnesite brick gives service at a considerably lower initial cost than the latter and is now being used successfully both in the electric and basic open-hearth furnaces.

**Refractories industry in 1935.** W. J. RUSSELL. *Foundry Trade Jour.*, 54 (1935) 122 (1935).—The progress in the refractory industry for 1935 is briefly outlined. The dry pressing of refractories has increased, especially at higher pressures, with the manufacture of "unburned" magnesite refractories. Attention is being directed to the production of fused refractories, both by casting the fused material into special molds and by machine-pressing the crushed and graded preformed material. The use of de-airing machines and carefully controlled tunnel kiln firing of refractories are described. With silica brick for steel melting furnaces, the trend is toward the use of well-constructed brick with a high tridymite content. There has been an extensive application of insulating brick. Basic refractories are being used for the roof and other parts of the basic open-hearth furnace. On the nonferrous side, increasing use is being made of sillimanite refractories. The increased publication of phase diagrams is of fundamental interest.

**Refractory and acidproof ceramic products.** W. G. LAMARCA. *Refract.*, 49, 43-45 (1934); *Chem. Abs.*, 29, 4910 (1935).—L. reviews particularly products and fire clay with their temperature diagrams and characteristics.

**Refractory building materials.** Testing methods (Poland). ANON. *Wiadom. Polsk. Komitet. Normalizacji*, 11 (4) 40-43; [5-6] 67-68 (1936); abstracted in *Refract. Silikoliterat.*, 3 (11) 3438 (1936).—Refractory building materials, including (a) artificial, fired, (b) natural, neither fired nor fired, (c) mortar and refractory masses, should have at least P.C.E. 25. A description of the following standard tests is given: (1)

**Effect of composition on properties of household porcelain.** A. N. ENOKOV. *Keram. & Staklo*, 12 (11) 25-29 (1935).—The composition of bodies and their behavior with respect to resistance to rupture, compressive strength, resistance of body, and deformation on firing, are discussed in detail. Results are tabulated. See "Influence—" *Ceram. Abs.*, 14 (5) 121 (1935).

**Effect of replacing dolomite lime by baryta upon some properties of glass.** VINCENT R. WISSMAN. *Jour. Amer. Ceram. Soc.*, 20 (3) 79-84 (1937).

**Heat conductivity of electrical conductors.** A. S. PRUDHOMME. *Zhur. Eksp. Teor. Fiz.*, 4, 838-54 (1934); *Chem. Abs.*, 29, 7780 (1935).—This section of modern conceptions of the nature of matter, a theory is developed and compared with data for a large number of metals.

**Heat conductivity of solid heat insulators.** A. S. PRUDHOMME. *Zhur. Eksp. Teor. Fiz.*, 4, 813-37 (1934); *Chem. Abs.*, 29, 7780 (1935).—On the basis of considerations as to acoustic waves in isotropic solids, a theory of heat conductivity is developed and compared with experimental data on NaCl, KCl, CaF<sub>2</sub>, SiO<sub>2</sub>, SiC, Si<sub>3</sub>N<sub>4</sub>, SiO<sub>2</sub>, glass, CaCO<sub>3</sub>, as marble and as calcite, ice, carbon steel, constantan, manganin, Bi, brass, Sb, chrome-nickel steel, and German silver.

**Nature of glass in a porcelain body.** SHU KONO and KIKUICHI MOYU. *Jour. Japan. Ceram. Assn.*, 41, 453-58 (1935); *Jour. Soc. Glass Tech.*, 18 (109) 5A (1934).—Results of optical measurements for forty-three porcelain bodies made of kaolin, feldspar, and quartz or kaolin, feldspar, and alumina are given. Each material was ground to pass through a sieve of 10,000 meshes/sq. cm. The members in the systems kaolin-feldspar-quartz and kaolin-feldspar-alumina were compounded and formed into small cones.

**After firing to 1400° and preparing this section, their microstructures were observed. This section of the system kaolin-feldspar-quartz consisted of glass, quartz, mullite, yellow spots, and pore, while those of the system kaolin-feldspar-alumina contained crystalline alumina in addition. The glasses were heterogeneous even in the same thin section. Solubility of mullite in the glasses is discussed. Their refractive indices were determined by the double variation method originated by R. C. RICHMOND (*Ceram. Abs.*, 8 (1) 70-71 (1929); 9 (2) 184; (3) 217 (1930); 11 (8) 498 (1932)) and improved by T. SANO. The relation between the refractive index and the chemical composition is shown by tables and triaxial diagrams. The general tendency is that quartz reduces the index, while alumina and kaolin increase it. See *Ind.*, 12 (10)-11 (8) (1935).**

**Porcelain sheaths for thermocouples.** V. TAAHEENKO. *Zashchita Lak*, 3, 1038 (1934).—A porcelain plate is fused to the end of a porcelain tube with an arc (10 to 15 amperes). Hot pulverized borax and clean sand are applied and the tube is heated once more. P.B. & R.S.

**Properties of newly discovered "pottery" materials and their uses.** SHUNICHIRO ONAGA and KOJI TERAZAKI. *Repts. Imp. Fuel Research Inst. Japan*, No. 17, pp. 1-36 (1935); abstracted in *Chem. Zvest.*, 1936, II, 3165.—Three kinds of pottery materials recently discovered were

obtaining an average sample, (2) determination of refractoriness, (3) determination of specific gravity, volume weight, and porosity, (4) absorption of water and apparent porosity, (5) resistance to pressure, and (6) chemical analysis of clay, quartzite, grog, and silica products.

**Refractory clays.** MOUNIER. *Rev. Fonderie*, 32, 405-406 (1935).—Refractory clays (the French words, not the usual "argile") are siliceous, pyrophyllitic clays, materials reduced to sand with a slight percentage of actual clay. They are often used simply stamped tightly and form an excellent lining material for furnaces, having, with 92 to 94% silica, a melting point of 1770°C., the softening point is very close to the melting point. When the clays are mixed with up to 6% alumina, the melting point is lowered, but beyond this up to 8.2% alumina the melting point increases again and approaches 1790 to 1810°C. The material is used frequently for lining electric furnaces. The composition of the deposits found in France and Germany is described. Brick made from this material is rather expensive.

**Refractory products.** V. BONIS. *Usine*, 54 (16) 27 (1935).—Refractories are defined as products whose fusion temperature exceeds 1500°C. They are divided into two groups: the Si-Al base and those not belonging to this group. The first group embraces all products of Si<sub>2</sub>Al<sub>2</sub>O<sub>5</sub> and silica alumina, such as bauxite and sillimanite; the second group consists of products of silicon carbide, graphite, zirconium, chrome-iron, and magnesia. The properties of the groups are briefly described, and points important for the selection of a material for a given case are discussed.

**Relation of air change to cupola operation.** H. J. CRAWFORD. *Trans. Amer. Foundrymen's Assn.*, 7 (1) 803-12 (1935).—The reactions that take place in the cupola and the best operation of such a furnace are shown. The cupola is divided into zones, and the function of each is explained. C. also explains the reactions that should take place within each zone and how improper control of the air supply, coke, and iron charges influences the thermal efficiency and consequently the melting efficiency.

**Relationship between durability in service and properties of refractory brick.** OTTO PULVER. *Brit. Dent. J.*, 45 (1937) 611-16 (1937).—Intensive plant tests were conducted on a powdered coal-fired mill furnace to determine the amount of wear and tear on the refractories, and the brick used for this purpose were subjected to laboratory tests to determine their chemical and physical properties. The practical tests in the combustion chamber of the mill furnace revealed that the refractories were subjected to considerable wear and tear, the most favorable case showing a 34.7% loss in volume after 600 hours of service. The laboratory investigation showed that this rapid failure is due mainly to the inability of all the fireclay material in withstanding long periods at the maximum temperature (1500°). Slag attack is of minor importance. The frequent changes of temperature proved detrimental to silica material. The brick tested also showed insufficient refractoriness under load strength for the working temperatures of the furnace. Special importance is attached to the determination of the inside wall temperature and the

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outer surface of the threading die and the inner surface of the opening, pressing the material of the wall of the opening into thread formation by means of the die, and venting the opening to atmosphere through the threading die during the entrance and removal of the die.

Soap dish for sinks. W. C. GOSWORTHY (John B. Pierce

Foundation). U. S. 2,070,010, Feb. 9, 1937 (Sept. 14, 1935).

Tank flush valve—ball type. W. C. GOSWORTHY (John B. Pierce Foundation). U. S. 2,068,072, Jan. 26, 1937 (July 5, 1935).

### Equipment and Apparatus

Abrasive mask. W. P. BUCK. *Eng. Mining Jour.*, 137 (12) 644 (1936).—The mask described was developed by the Navy Department for the prevention of silicosis. A latex-covered silk hood fits over the head and shoulders of the operator, leaving exposed only the lens section of the face piece. Air is fed into the face piece through a regulated rubber tube and passes out through double exhaust valves with extremely low resistance to air flow. The mask has a flow-control valve and can also be instantly detached from the air line so that the operator can breathe through a filter in the free end of the corrugated tube. Illustrated.

Apparatus for measurement of shrinkage coefficient of soils. B. N. SIMON AND P. B. MATTHEW. *Soil Sci.*, 43 (1) 37-41 (1935).—A simple apparatus for measuring the shrinkage coefficient of soils is described. A few data on the shrinkage coefficient and the relative moisture capacities of a number of soils are presented.

Apparatus for sampling gases at a constant rate. A. BLACKEN. *Jour. Soc. Chem. Ind.*, 55 (12) 307-308 (1936).—B. describes a simple device by means of which a gas sample can be taken from a moving stream of gas at a constant rate over a period of time. The theory and method of operation are given. Tests have shown that the rate of collection of sample remains constant throughout the whole sampling period. Illustrated.

Classification of drying, including graphical analysis of air drying as developed abroad. A. WEINBERGER, CHAULEN W. THOMAS, AND T. R. OLIVER. *Trans. Amer. Soc. Mech. Engrs.*, 57, 11-47 (1935).—Drying is defined as the removal of evaporable liquids by the use of heat as contrasted with dehydration by mechanical means. Terms applying to drying are described. Formulas and curves are derived for the determination of the rate of drying and the heat required. The effect of diffusion of the liquid through the solid is considered.

De-airing in an ordinary pug mill. KENNETH STEVENSON. *Jour. Amer. Ceram. Soc.*, 20 (1) 87-88 (1937).

Determination of coal grindability by the ball-mill method. C. G. BLACK. *Amer. Inst. Mining Met. Engrs. Contrib.*, No. 95, 23 pp. (1935); *Brit. Chem. Abstr.*, 35 (21) 432 (1935).—A critical examination is made of the A.S.T.M. Tentative Standard ball-mill method in which the grindability is determined by the number of revolutions of the mill required to reduce 80% of the feed (50 g. of 10 to 20-mesh coal) to pass 20-mesh. Tests made with a wide variety of coals indicate that in order to get the true grindability of a coal, the sample must be ground to the same surface area. It is suggested that the method be modified by taking constant initial volumes and grinding until 80 wt. % passes 20-mesh. The manner of preparing samples and the possibility of introducing mechanical screening and of reducing the

test time required are also discussed. It is concluded that one method only should be chosen as a standard because the results obtained by the ball-mill and the Hardgrove-machine methods, now tentative standards, are not comparable.

Developments in the battle against corrosion. V. A. ROHLIN AND C. E. JOKA. *Combustion*, 8 (1) 25-29 (1935).—The authors discuss the principles and problems involved in the mechanical de-airing of boiler feedwater to meet the exacting demands of recent practice and describe two late types of de-airing heaters. One is the tray type in which the flow of water and steam are parallel; the other employs the counterflow principle and operates by spraying and atomizing without the use of trays.

Dial thermometers. AMERICAN SCIENTIFIC & BUSINESS CO., CONSOLIDATED AMERICAN HANCOCK CO., INC. *Instrum. Eng.*, 10 (1) 6 (1937).—This is said to be the only dial thermometer with all parts made of corrosion-resistant material (stainless steel). The moisture- and dust-proof case is made of a phenol condensate and has a shatter-proof front. The thermometer may be used for temperatures from -40 to 1000°F and at distances up to 1000 ft. The thermal system is mercury filled.

Electromagnetic separators, with special consideration of the ceramic industry. G. S. ULANOV. *Rev. Ind. Ceram. Ges.*, 16 (5) 243-252 (1935).—Modern electromagnetic separators which can be used in the ceramic industries to remove iron and iron-bearing silicates from both raw materials and ceramic bodies are described in detail. These range from the simple electromagnet, over which the material flows, to complicated machines. Illustrated.

E. J. V.

Experimental investigation of radiation heat exchange in combustion chambers. M. S. VANDERKAM. *Phys. U.S.S.R.*, 3 (3) 197-208 (1935); abstracted in *Physik. Ber.*, 17 (20) 1859 (1935).—While determining the distribution of radiation in a combustion chamber it was observed that the lenses used in radiation pyrometers are transparent for only part of the spectrum. For industrial conditions, only metal reflectors or fluoropar lenses should be employed which transmit the waves from 0.6 to about 10 μm occurring in flame spectra. Measuring methods are described in detail.

Gas-tight furnace for thermocouple standardization. D. C. NEVIN. *Can. Jour. Research*, 14 (1) 177-80 (1935).—A detailed description of a redesigned gas-tight furnace for calibrating Pt-PtRh standard thermocouples in sulfur acids is given.

Hardness and hardness measurements: I. S. R. WILLIAMS. *Instrum. Eng.*, 10 (1) 12-14 (1937).—Fields in which hardness measurements are particularly important are discussed.

R. W. R.

Heat-enduring alloys aid in casting huge telescope disk.

R. STUART BROWN. *Ind. Heating*, 4 (1) 37-38 (1937).—Cores in the glass mold were held in place by anchors of calite alloy (20% Cr, 10% Ni alloy) which withstood the temperatures without burning off as had other core holders.

Heat-resisting alloys. J. P. KATNER. *Powder Trade Jour.*, 54 (1011) 10-12 (1935).—To be able to judge whether or not a heat-resisting metal may be economically applied for a particular purpose, it is necessary to thoroughly appreciate the nature of the conditions under which the metal will have to work. The real strength of the metal must be known as well as the strength at elevated temperatures. Various types of heat-resisting alloys, such as Ni-Cr-Fe, Fe-Al, Fe-Si, and Cr-Al-Fe, are discussed. Surface protection by spraying, anodizing, and plating is considered. A discussion is included.

Hood respirator. DE VILHES CO. *Ind. Finishing*, 13 (3) 58 (1935).—The respirator covers the entire head and neck to give complete protection against materials present in the air which are harmful to eyes, ears, or respiratory organs. Air flows into the hood through a filter, diffuses throughout, and flows out through the opening provided for vision. The hood fastens around the neck with a draw string. Illustrated.

Humidity control device for ovens. C. T. WENGER. *Jour. Soc. Instrum. Eng.*, 13 (12) 413-18 (1935).—W. employs the principle of the wet- and dry-bulb thermometer to control the humidity in an electric oven. The arrangement described can be used to maintain the humidity at any desired value between 25 and 90% within  $\pm 1\%$  over a range of temperatures. Illustrated.

Improved motion-study camera and projector. PRODUCTION CONTROL MACHINES CORP. *Instrum. Eng.*, 10 (1) 8 (1937).—A new camera with a stronger motor and additional adjustments and a new projector with a larger lamp are now available. The apparatus uses 8-mm. film, available in 25- and 100-ft. reels.

Laws of drying of solid bodies. C. C. ARPLE. No. 155, p. 18 (1935).—The forces which produce the phenomenon of drying are diffusion and capillarity. Drying is discussed in regard to (1) velocity of constant drying, (2) phase in which the pressure of the humidity coming from within diminishes until the velocity of the surface layer is entirely extracted, and (3) internal resistance. Reference is made to the researches of Shewwood (*Brit. Ind. Rev.*, 1929); *Ceram. Abstr.*, 9 (7) 688 (1930); and Knecht (*Bull. Assoc. German Engrs.*, Aug. 8, 1930).

Magnetic detectors for industrial applications. R. F. EDGAR. *Gen. Elec. Rev.*, 39 (11) 559-62 (1935).—Various types of magnetic detectors for the inspection of non-metallic materials, the magnetic analysis of nonmagnetic materials, and assurance of the presence of essential concealed iron are described. Illustrated.

Magnetic separators to determine quartz sand. S. V. ROBIN. *Ceram. & Shale*, 12 (10) 15 (1935).—A brief discussion of a magnetic separator for extracting weakly magnetic minerals during declassification of quartz sand is given.

M. V. C.

Measuring dust. S. C. BLACKBURN. *Discovery*, 17 (20) 947-50 (1935).—Instruments described for the study and measurement of dust are the kometimeter, jet dust counter,

thermal precipitator, settlement counter, and electrometer.

Mechanical power transmission. G. A. VAN BUREN. *Factory Management & Maintenance*, 94 (11) S321-22 (1935).—The subjects considered are (1) group and individual systems, (2) laying out group drives, (3) use of unit drives, (4) speed reduction, and (5) obtaining variable speeds. Five tables, 14 photographs.

Method of testing the mechanical resistance of glass. R. KERNY AND R. WYATT. *Rev. Ind. Ceram. Ges.*, 17 (5) 387-91 (1935).—A new apparatus constructed from the mechanism of an electric gramophone is described. The test piece, a circular disk of glass porcelain 80 to 100 mm. in diameter, is fixed firmly to the turntable. A box having a number of holes bored through it is held between two brass rods, above the test piece. Closely fitting copper rods are passed through the holes in the box, and their lower ends rest on the test piece. By means of brass casings fitted to the top of the copper abutting rods it is possible to maintain a constant weight merely by introducing small shot into the casings. The ends of the rods resting on the glass must be carefully rounded off and smoothed with sandpaper before each test. The weight of each rod with the brass casing and shot in it was exactly 40 g. The r.p.m. of the motor should not exceed 100. For each test the test piece was measured with a mixture of cerium and glycerine, and the test lasted exactly 15 min. A determination of the loss in weight by abrasion for a number of materials was found to be as follows: German hard porcelain, 14 to 18 mg.; American chinaware, 20 to 25 mg.; earthenware (hard and soft of various makes) 25 to 45 mg. Illustrated.

Methods of testing thermocouples and thermopiles. W. F. ROSSER AND H. T. WARDEN. *Jour. Research Nat. Bur. Standards*, 14 (8) 247-82 (1935). R.P.765. Price 5¢.—Methods used for testing thermocouples and thermopiles materials are described, and the precautions which must be observed to attain various degrees of accuracy are given. Methods developed and used at the National Bureau of Standards are described in detail. Guidance is given in selecting the method which is best adapted to a given set of conditions. R. A. H.

Multiple grinding of thin-section chips. CONRAD K. WINTWORTH AND FRANCIS T. SZCZAK. *Amer. Jour. Sci.*, 34, 93-99 (1935).—An apparatus which will grind 20 to 25 rock chips at one time is described. It reduces the chips to 0.5-mm. thickness in preparation for the grinding of a thin section.

New spectrophotometer and some of its applications. J. L. MICHAELSON AND H. A. LIEBHAFETZ. *Gen. Elec. Rev.*, 39 (10) 445-50 (1935).—The spectrophotometer consists essentially of a double-slit monochromator, a photoelectric photometer, and a graphical recorder. The features of the construction and advantages of the design are outlined. A discussion of its application in fields of industrial control, color specification, analysis, and research is given. Illustrated.

Portable gas-analysis recorder. PERMUTIT CO. *Instrum. Eng.*, 10 (1) 7 (1937).—New portable "Rabbits" gas analyzers employing the specific weight principle may be operated on lighting circuits or standard 6-volt automobile batteries. These instruments may be used for de-

termining the carbon dioxide content of boiler flue gases or furnace atmospheres, air-fuel ratio of internal-combustion engine exhaust gases, and specific gravity of manufactured or natural gases. In the model for internal-combustion engines a pressure and vacuum gauge is built into the apparatus.

Preparation of ceramic raw materials with a Grangit sugar separator. GILBERT. *Rev. Ind. Ceram. Ges.*, 16 (8) 420-31 (1935).—G. describes the Grangit separator, in which the sugar is magnetized and serves to remove the iron and iron-bearing minerals from the raw material being ground. Specific instances of its application in actual practice, e.g., in the separation of feldspar from quartz, are given. Illustrated.

Preparation of kaolin, chalk, etc., by centrifuging. H. MAEST. *Rev. Ind. Ceram. Ges.*, 16 (5) 240-43 (1935).—M. discusses the use of the centrifuge for separating kaolin from its associated minerals due to the difference in specific gravity of the various materials. He discusses the principle of the process in detail, using different makes of centrifuges for illustrating the various points. E. J. V.

Pressure losses for fluid flow in curved pipes. GABRIEL H. KUTLAKOV AND K. BELAZNE BELL. *Jour. Research Nat. Bur. Standards*, 18 (1) 89-114 (1937). R.P.905. Price 10¢.—Results are given of a study of the flow of water in smooth-walled, large-radius pipes for the viscous and turbulent regions over a range of Reynolds numbers from 500 to 60,000. The discussion is based on data obtained with 1/4-in. brass tubing.

Simple method of obtaining fine hair lines for use with telescope or microscope. J. R. HAYNES. *Rev. Sci. Instrum.*, 8 (3) 166 (1936).—Fine straight fibers for use as hair lines or scale markings in a telescope or microscope may be easily obtained by drawing a small globe of rubber cement at the point of a pin. If permanence is desired, the fibers should be reinforced with glass. This is done by selecting the end-points on a glass plate so that the fibers will lie wholly on the surface of the glass. The hair lines may be erased from the glass by means of a bit of cotton moistened in carbon tetrachloride.

Standard tables for chromel-alumel thermocouples. W. P. ROSSER, A. I. DARR, AND G. J. GOWANS. *Jour. Research Nat. Bur. Standards*, 14 (3) 239-56 (1935). R.P.767. Price 5¢.—Tables have been prepared giving the thermal e.m.f. of chromel p. s. alumel, chromel p. s. platinum, and alumel s. platinum at various temperatures in the range -310 to 2500°F. The values in the range 0 to 2500°F are based on the calibration of 15 representative No. 8 gage chromel-alumel thermocouples selected after preliminary tests on 50 heats of each alloy made by the method regularly used. The tables give the temperature-e.m.f. relation of the thermocouples now manufactured as closely as the wires can be reproduced at the present time. The guarantee limits have been fixed by the manufacturer at  $\pm 0.1^\circ\text{F}$  in the range 0 to 600°F and  $\pm 0.5^\circ\text{F}$  in the range 600 to 2500°F. The methods used in calibrating the thermocouples in the various temperature ranges are briefly described.

Theory of drying. OTTO TH. KÖRBER. *Deut. Vollen-Gewerbe*, 66, 105-107 (1934); *Chem. Abstr.*, 29, 7704 (1935).—Factors involved in all cases of industrial drying which influence the amount of heat necessary for the drying

chamber are (1) total heat of the saturated steam, (2) raising the saturated steam to the temperature of the heating gases, (3) amount of heat required to heat the material, (4) amount of heat necessary to raise the drying chamber and walls to the drying temperature, and (5) amount of heat which must be added to compensate for nonpreventable losses due to conduction, radiation, convection, and waste gases. For all technical heat calculations of air-drying installations it is necessary to take the physical laws for moist air as the basis, with the specific heats of air and steam constant. The warm air can pass through the drying room either naturally or by means of an exhaust or a blower. The warm-air velocity and drying time must be carefully determined. For economic reasons it is also advisable to measure daily the steam consumption and to compare it with the water converted into steam.

Thermal expansion of cemented tungsten carbide. PETER HILTZNER. *Jour. Research Nat. Bur. Standards*, 18 (1) 47-52 (1937). R.P.900. Price 5¢.—H. gives data on the linear thermal expansion of tungsten carbide mixtures containing about 6 to 13% of cobalt. These products are known as Carboloy in the U. S. The average coefficient of expansion of cemented tungsten carbide containing 5.9% of cobalt increases from  $4.4 \times 10^{-6}$  for the range between 20 and 60°C to  $5.9 \times 10^{-6}$  for the range between 300 and 400°C. The average coefficients of expansion for samples containing from 12.9 to 13.2% of cobalt increase from  $5.0 \times 10^{-6}$  for the range between 20 and 60°C to  $6.7 \times 10^{-6}$  for the range between 300 and 400°C. The rates increase linearly with temperature.

Thermionic relay circuit for a.c. or d.c. used for use with a thermoregulator. P. L. TUCKER. *Jour. Sci. Instrum.*, 13 (12) 414-15 (1935).—An improved form of vacuum tube relay is described for control of a thermoregulator or any other type of switch which passes only a very small current. Illustrated.

Time-cycle controllers and metallic mercury switches. ELECTRIC SWITCH CORP. *Instrum. Eng.*, 10 (1) 5 (1937).—For controlling machine operations electrically by means of solenoids and magnets in definite timing sequence, two general types of time-cycle controllers using new metallic mercury switches have been designed. The controller operates one or two circuits at the rate of 15, 30, 45, or 60 makes and breaks per min. by means of a shaded pole a.c. (or universal) motor operating a cam and rocker arm. The quickly operating metallic mercury switches are described. These operate on tipping through an angle of approximately  $10^\circ$  from the horizontal and are supplied in 5-, 10-, and 15-ampere capacities and in various voltages.

True and apparent impact strength. OTTO RABENST. *Rev. Ind. Ceram. Ges.*, 17 (6) 281-95 (1935).—Impact strength values obtained by the usual methods can not be taken as a measure of the true resistance to impact since they contain, in addition to the energy required to break the test piece, a certain proportion of kinetic energy which is shown in the force with which the fragments of the specimen are thrown forward. The true impact strength is the amount of energy required to break the specimen only. A method for determining this directly is described. With fireclay bodies the true impact strength is only 25 to 40%

of the apparent impact strength. It is possible to calculate the true impact strength from the apparent impact strength values. The proportion of residual kinetic energy produced in determining the apparent impact strength by the usual methods depends mainly on the weight and partly on the shape of the test piece. It is therefore suggested that when reporting the impact strength values, the weight and shape of the test specimen should be clearly stated.

Viscometer for ceramics. NEUMANN. *Rev. Ind. Ceram. Ges.*, 16 (3) 61-33 (1935).—A modified viscometer with an inverted cone-shaped bottom is described, and the method of using it is explained. Its operation is said to be more simple than that of instruments in common use. Illustrated.

E. J. V.

Mining and grinding methods and costs at the Denison Sower Pipe Co. clay mine, Denison, Ohio. H. J. LEITCH. *U. S. Bur. Mines Information Cir.*, No. 6921, 16 pp. Free.

Mining and grinding methods and costs at the Evans Pipe Co. clay mine, Uhrichville, Ohio. R. J. LEITCH. *U. S. Bur. Mines Information Cir.*, No. 6929, 18 pp. Free.

Suggested methods for the reduction of mine accidents from the viewpoint of the safety engineer. E. H. DUNN. *U. S. Bur. Mines Information Cir.*, No. 6925, 6 pp. Free.

Time-cycle controllers and metallic mercury switches. ELECTRIC SWITCH CORP. *Instrum. Eng.*, 10 (1) 5 (1937).—For controlling machine operations electrically by means of solenoids and magnets in definite timing sequence, two general types of time-cycle controllers using new metallic mercury switches have been designed. The controller operates one or two circuits at the rate of 15, 30, 45, or 60 makes and breaks per min. by means of a shaded pole a.c. (or universal) motor operating a cam and rocker arm. The quickly operating metallic mercury switches are described. These operate on tipping through an angle of approximately  $10^\circ$  from the horizontal and are supplied in 5-, 10-, and 15-ampere capacities and in various voltages.

Apparatus for applying color or glaze to tile. W. ROULTON, LTD. AND H. H. HALL. *Brit.*, 458,577, Jan. 7, 1937 (June 15, 1935).

Apparatus for producing brick closed on five sides. P. KOHN. *Brit.*, 457,228, Dec. 9, 1936 (Oct. 12, 1935).

Apparatus for separating materials. A. C. WENDLER. *U. S.*, 2,068,783, Jan. 26, 1937 (Sept. 29, 1932). The separating apparatus consists of an inclined material-separating screen maintained under tension, means for imparting low-amplitude high-frequency vibrations to the screen, means providing a plurality of separate compartments above the screen, and respective means of filter particles in the compartments.

Antitrache for firing ceramic ware. YU. YU. BERNSEN. *Ceram. & Shale*, 12 (10) 22-25 (1935).—Directions for firing antitrache in ceramic furnaces are given.

M. V. C.

Clay-cutting device. ERNEST FREY. U. S. 2,069,944, Feb. 9, 1937 (March 7, 1935). An automatic clay-cutting device, in combination, clay-feeding means, a carriage, a plurality of cutters arranged for reciprocation at substantially right angles to the carriage, and automatically operative means for angularly displacing each of the cutters between two cutting positions in the direction of feed.

Conditioning of freshly quarried clay. BIRD MACHINE CO. *Brit.*, 459,779, Jan. 27, 1937 (Nov. 28, 1934).

Machine for making brick, tile, etc. W. JOHNSON & SONS (Lancs), LTD., A. ROSSMAN, AND E. A. MANN. *Brit.*, 458,107, Dec. 23, 1935 (June 15, 1935).

Machine for shearing blocks from an extruded column of plastic material. ERNEST FREY. U. S. 2,069,947, Feb. 9, 1937 (March 7, 1935). An automatic machine for shearing blocks from a column of clay is described.

Method and apparatus for producing porous lightweight aggregate from liquid slag. E. B. BJORKMAN. *Brit.*, 457,707, Dec. 16, 1936 (May 3, 1935).

Method of coating surfaces. H. V. SCHWETTER AND D. A. CASAS (United States Quartz Tile Co.). U. S. 2,068,892, Jan. 26, 1937 (June 6, 1932). The method of applying fusible glazes, enamels, and similar coatings to earthenware, tile, metal, and other nonabsorbent materials consists in spraying a mixture of liquid and the fusible material on the surface of the nonabsorbent material and directing a hot gaseous stream toward and intersecting the stream of the sprayed mixture after it has been sprayed but prior to its impingement on the surface to drive the mixture through the mixture, thereby to effect adherence of the mixture to the surface without further flow thereof.

Method and means of collecting dust from an air current. R. F. KNEUBER (American Floor Surfacing Machine Co.). U. S. 2,068,829, Jan. 19, 1937 (June 24, 1935).

Production of foamed slag from liquid slag. E. B. BJORKMAN. *Brit.*, 457,774, Dec. 16, 1936 (June 4, 1935).

Purification of material deposits. R. W. FLINN. U. S. 2,070,175, Feb. 9, 1937 (Jan. 21, 1935). The method of purifying material deposits is finely divided form in an oven comprising passing the material continuously through the oven, passing a continuous stream of chlorine gas through the oven, agitating the material during passage through the oven to obtain intimate mixture of gas and material particles, applying a heat gradient to the streams through the oven whereby different combinations of the gas and impurities in the oven will occur in different locations within the oven, and separately removing the different combinations.

Kilns, Furnaces, Fuels, and Combustion  
Experiments with combustion control. T. E. CROSBY AND A. J. MATTHEWS. *Combustion*, 8 (1) 35-38 (1935).—The authors describe the combustion-control system installed to operate on natural gas and give oper-



ing experiences when the fuel averages 70% natural gas and the remainder petroleum coke breeze and acid sludge. Fuel oil is used when the natural gas supply is interrupted.

**Firing and cooling of yellow iron-oxide clinker from a carbonaceous clay, and the changes in porosity and color occurring during the process.** R. TOSUMATSU. *J. Res. Nat. Bur. Stand., Ser. A*, 67 (1962) 177-183 (1962).—The raw material used in this investigation is found in Högåsa, Sweden. Due to its carbon content of 1 to 2%, a special firing schedule is necessary. Firing curves followed in a gas-fired chamber kiln are reproduced. By using the draw trial method and examining the specimens for porosity, the changes taking place in the body were followed through the entire firing treatment. To attain a desired color, a definite cooling time must be maintained in the range of 1300 to 1000°. The various effects caused by the iron in the clay, according to the different firing treatments, are described. Illustrated.

**Fuel meter for furnace combustion control.** S. F. BOWMAN & Co. *Instrument. Eng.*, 10 (1) 3 (1957).—A new furnace combustion control for heavy oils and tars uses a new "Flowing Register Measure" for high-temperature service (50 to 200°F). This fuel meter is equipped with a 6-inch cyclometer for quantity metering and also drives a tachometric d-c generator. The 1/2-in. size is recommended for flows not exceeding 8 to 10 gal./min. and not less than 1 gal./min. Viscosity limits for metered fuels are 400 to 10,000 sec. Saybolt Universal. A steam jacket is available. Flow-rate indicators and recorders are standardized electric tachometric units calibrated in g.p.m. when operating from a standard generator.

**Fuel technology.** ANON. *Trans. R. Soc. Lond.*, 207 (1957).—The newest methods for producing liquid fuel, solidified fuel, oil, and motor spirit from coal are given with notes on trends in the treatment of coal for these purposes.

**Heat transfer in electric furnaces.** R. G. FROBENIUS. *Exp. Eng.*, 156, pp. 377-79 (Oct. 20, 1957).—Abstracted in *Jour. Iron & Steel Inst. (London)*, 129 (1) 619 (1954).—Furnaces approximate distribution of heat in electric resistor-type furnaces used for the annealing and heat treatment of steel castings. Such furnaces are generally run at about 1750°F, the maximum temperature desired in the castings being about 1650°F. The average oil-fired annealing furnace, without recuperation, has an overall efficiency of approximately 35% only, and of the total heat input about 50% escapes to the exhaust. As a result of the low efficiency, only 12 to 15% of the whole heat supplied goes to heat up the brickwork, and its rate of transfer becomes of minor importance. In the electric furnace there is no stack and the loss of heat in escaping gases is relatively small; consequently a much larger proportion of the heat input is absorbed by the brickwork.

**Hydrogenation.** F. S. SODHATY, J. G. KINO, AND ANON. *Macmillan, Ind. Eng. Chem.*, 29 (1) 133-40 (1957).—In 1933, experimental work on hydrogenation was started to ascertain whether British bituminous coals could be readily converted to gasoline. After a study of catalysts, an experimental plant of one ton per day capacity was constructed. The construction and operation of the semi-technical-scale tar hydrogenation plant now in

use is described together with analyses of the raw and treated tars. Temperature conditions in the catalyst chamber and means for dissipating the heat of reaction are discussed. Illustrated.

**Mechanism of combustion of carbon particles under atmospheric pressure.** V. I. BLINOV. *Izv. Akad. Nauk SSSR, Khim. Nauk*, No. 7, pp. 8-17 (1957).—Chem. Abstr., 29, 4550 (1955).—The weight of a small graphite ball suspended in a furnace was checked at varying temperatures by means of a microbalance. At 700° the ball became heated up to the furnace temperature without changing its weight; above this temperature the weight began to decrease gradually. The weight decreased rapidly at 740 to 760°; this decrease was accompanied by a blue flame. The flame disappeared after a time and the temperature remained stationary during the combustion. Details of the experimental conditions are given and the results are calculated. 20 references.

**Oxidation of anthracite; liberation of carbon monoxide and its relation to ignition temperature.** G. S. SCOTT AND W. J. JONES. *Ind. Eng. Chem.*, 29 (1) 106-108 (1957).—A method and apparatus are described for obtaining the relative rates of liberation of carbon monoxide from carbonaceous substances during heating and for determining the ignition temperatures at the same time. The tests were designed primarily to identify quickly the most readily ignitable coals; other materials found in an anthracite mine. Special emphasis is placed on the rate at which carbon monoxide was liberated when the carbonaceous materials were heated at a constant rate in the presence of air. The initial temperature and rate at which carbon monoxide is liberated have a direct or indirect relation to the tendency of carbonaceous materials to heat spontaneously. Illustrated.

**Possibility of calculating the heating value of a fuel from elementary analyses.** TORSTEN WIDELL. *Ing. Vet. 67* (1955).—Chem. Abstr., 29, 5091 (1955).—Results obtained by the various known equations for calculating heating values from elementary analyses are compared graphically. Exact determination is impossible. There are wide divergences.

**Sludge in heavy grades of fuel oil.** ANON. *Chem. Ind. (London)*, 17 (1) 377-78 (1957).—In adopting heavy grades of fuel oil for heating glass tanks, new operating difficulties have arisen, chiefly from the deposition of carbon or carbonaceous material formed when oils are subjected to excessive cracking. During storage the suspended particles accumulate and the sludge tends to settle out. This sludge feeds lines and burners and causes difficulty in maintaining even combustion. Cracked residues also have high ash content. Sludge content and tendencies to form sludge should be checked before oil is purchased. Experiments carried over from light oil to the Duncker "C" type. Methods of determining sludge are given. Particles of sludge falling on the glass give rise to blisters and steady glass due to their slow oxidation. The high iron content of the ash often causes color glass in furnaces using cracked residue oils. A gravity settling system and filtration of the oil help to remove sludge, but the most practical and economical sludge-removing method is by use of the centrifuge.

E.J.V.

**Carbonizing properties and petrographic composition of Glintwood bed coal from Buchanan mines Nos. 1 and 2, Buchanan County, Va.** A. C. FRIEDLANDER, J. D. DAVIS, R. THURMAN, W. A. SALVIO, D. A. REYNOLDS, F. W. JUNG, AND G. C. SPENCER. *U. S. Bur. Mines, Tech. Paper*, No. 570, 34 pp. Price 10¢. This is the 12th of a series of papers covering a survey of gas, color, and by-product making properties of American coals being conducted by the Bureau in cooperation with the American Gas Assn. The field and quality are given for products obtained at carbonizing temperatures of 600°, 800°, and 1000°, using a retort 12 in. in diameter, and at 800°, 900°, and 1000°C, using a retort 18 in. in diameter. Results of

chemical, physical, and petrographic studies of the coal are also given. Pittsburgh bed coal from Pittsburgh Terminal No. 9 mine, Washington County, Pa. *Ibid.*, No. 571, 33 pp. Price 10¢. The yield and quality is given of products obtained at carbonizing temperatures of 600°, 800°, and 1000°C, using charges of 85 lb. and at 800°, 900°, and 1000°C, using charges of 185 lb. Results of chemical, physical, and petrographic studies of the coal are also given. R.A.HENRY.

## PATENT

**Electric furnace wall construction.** T. H. FOSTER (Disco Corp., Ltd.). U. S. 2,602,241, May 21, 1953 (Oct. 30, 1951).

## Geology

**Accelerated weathering of feldspars.** F. H. NORTON. *Amer. Mineralogist*, 22 (1) 1-14 (1957).—A reaction chamber for carrying on the accelerated alteration of feldspars under constant temperature conditions has been developed. The reaction simulates natural conditions because fresh liquid is constantly supplied to the sample, and the soluble reaction products are constantly removed. Orthoclase was changed to sericite and anorthite to pyrophyllite under the particular conditions of the test, water and carbon dioxide being used as solution materials. The maximum temperature limits for these reactions were tentatively established as 250°C for orthoclase and 300°C for anorthite. Albite has been partially decomposed, but the end products have not been identified as yet. F.J.Z.

**Adsorption complex of mineral soils.** D. J. HINCHES, JAC. VAN DER STREE, AND S. B. HOOGMOED. *Trans. Internat. Congr. Soil Sci., 3rd Congress, Oxford, 1955*, 1, 82-84; *Chem. Abstr.*, 29, 7545 (1955).—Four clay soils were worked up as for mechanical analysis by the international method ( $\text{H}_2\text{O}-\text{HCl}-\text{NH}_4\text{OH} + \text{NaOH}$ ) and decanted with Atterberg cylinders to secure the fractions (a) 10 cm, 8 hr., less than 2%; (b) 10 cm, 30 min., 2 to 8%; (c) 10 cm, 7.5 min., 8 to 16%; the residue was sieved to secure (d) 16 to 42 $\mu$ . Suspensions of these fractions were electrolyzed to remove all bases. It is noted that to prevent decomposition of the aluminum-silicate complex during dialysis, humus must be absent. The dialyzed fractions were analyzed by  $\text{NaClO}_4$  fusion and further examined by van Bemmelen's procedure for weathering silicates. (1) removed by 25% HCl followed by NaOH treatment; and (2) removed from the residue by boiling with  $\text{H}_2\text{SO}_4$  followed by NaOH treatment. Hinches's  $T - S$  value was also determined from  $\text{Ba}(\text{OH})_2$  absorption; since  $S = 0$ , this gave  $T$  directly. In (1),  $S$  is the molecular ratio  $\text{Al}_2\text{O}_3/\text{SiO}_2 \cdot \text{H}_2\text{O}$  decreased with increasing particle size;  $T$  tended to decrease but was sometimes at a maximum in a coarser fraction. (a) contained around 90% of (1), (b) 6.9% maximum, (c) 2.8% maximum, and (d) 4.5% maximum. There was a striking parallelism between percentage of (1) in the fractions and  $T$  values per 100 g., whence it is concluded that (1) dominates adsorption capacity. Similar experiments on kaolin and ground quartz fractionated to less than 2 $\mu$  and electrolyzed showed small values for  $T$ , proving

that the adsorptive property is not dependent upon particle size alone but on specific chemical properties. The  $T$  value of (1) from (a) fractions was 1.35 to 1.24 mg. equivalent / g., but lower values, down to 0.76, were obtained for other fractions. (1) of (a) is believed to be a Mg K Al silicate; (b), (c), and (d) are largely quartz. Determinations by the cation and quinhydrone electrodes showed that (a) was invariably very acid,  $\text{pH}$  2.6 to 3.7 in 1:2.5  $\text{H}_2\text{O}$  suspension. Ultrafiltrates of these suspensions were approximately neutral, with one exception,  $\text{pH}$  2.4; the addition of (c) to ultrafiltrate produced low  $\text{pH}$  values, indicating activity of solid particles as a source of  $\text{H}^+$ . Further investigations are outlined.

**Adsorption of liquids by clays.** E. W. RUSSELL. *Trans. Internat. Congr. Soil Sci., 3rd Congress, Oxford, 1955*, 1, 45-50; *Chem. Abstr.*, 29, 7551 (1955).—The factors in which the apparent density of clay in different liquids depends are analyzed. Clays are indicated to absorb nonpolar liquids weakly or not at all; the adsorption of polar liquids is due to the orientation of electric dipoles in their molecules in the electrostatic field around exchangeable ions held by the clay and around the negative charges on the latter.

**Applicability of alkaline permanganate for oxidation of organic matter in soils for mechanical analysis.** J. N. CHAKRABORTY. *Soil Sci.*, 42 (4) 261-66 (1956).—A method of mechanical analysis using alkaline permanganate for oxidation of organic matter yields comparable results with the International-A method in the case of various Indian soils, e.g., ordinary sandy, forest, gypsum, peat, and lateritic soils. Thus the method appears to be a general one for mechanical analysis of soils. It is particularly suitable for soils rich in organic matter and is recommended for use in the tropics where hydrogen peroxide is not available. Alkaline permanganate requires only a short time for oxidation of organic matter. Soils containing gypsum should be passed through a 70-mesh sieve after oxidation with alkaline permanganate and before addition of hydrochloric acid. 6 references.

**Associative and antagonistic effects of microorganisms. I. Historical review of antagonistic relationships.** SELMAN A. WAKSMAN. *Soil Sci.*, 43 (1) 61-68 (1956).—A survey of the literature on the antagonistic relationships of microorganisms, with special reference to those that make up the

complex soil population, reveals certain important points which are summarized as follows: Numerous organisms bring about injurious or destructive effects upon themselves or upon other organisms. In some cases, the injurious effect may be due to competition for nutrients; in other cases it is due to a change in the environment. The conditions of the substrate, especially oxidation-reduction potential and reaction. More frequently it is due to the formation of substances which exert a definite toxic effect. The production of these toxic substances is greatly influenced by the reaction, temperature, and aeration of the substrate as well as the presence of other organisms.

**Antagonistic effects of microorganisms grown on artificial substrates.** SELMAN A. WAKSMAN AND J. W. FOSTER. *Ibid.*, pp. 69-70. (1) 133-40 (1957).—In 1933, experimental work on hydrogenation was started to ascertain whether British bituminous coals could be readily converted to gasoline. After a study of catalysts, an experimental plant of one ton per day capacity was constructed. The construction and operation of the semi-technical-scale tar hydrogenation plant now in

use is described together with analyses of the raw and treated tars. Temperature conditions in the catalyst chamber and means for dissipating the heat of reaction are discussed. Illustrated.

**Blinding forces between clay particles in a soil crumb.** R. W. RUSSELL. *Trans. Internat. Congr. Soil Sci., 3rd Congress, Oxford, 1955*, 1, 20-20; *Chem. Abstr.*, 29, 7551 (1955).—The hypothesis is advanced that clay particles are held together in a soil crumb by oriented molecules of a polar liquid; the molecules of this liquid are various liquids as dispersion media. Only polar liquids produce hard crumbs. Exchangeable cations serve as the connection between clay particles in crumbs, linking the latter through their large negative charges. The cation must also be small; large molecules of certain organic liquids of high molecular weight produce only soft crumbs. See *Chem. Abstr.*, 14 (5) 124 (1955).

**Centrifuged and elutriated kaolin.** LAURENCEMINA AND R. WAGNER. *Sprechz.*, 69 (30) 59-64 (1956).—Comparison tests were made on samples of washed and centrifuged kaolin. The advantages of the Hertzsch centrifuge (Krupp-Gruenow, Magdeburg) over elutriation and its operation are explained.

**Ceramic investigations of concentrated Chav-Yar ow-grade clays ("balyk").** A. I. KHAMAMENKO AND SKEDINA. *Ognepry*, 3 (5) 387-92 (1955).—A material with the same alumina content as the high-grade clays of this deposit and with a higher plasticity is obtained by concentration.

**Chemical and physical changes in soil colloids with advancing development in Illinois soils.** R. H. BRAY. *Soil Sci.*, 43 (1) 1-14 (1956).—The study includes five profiles varying in profile development and weathered condition. Development took place under a humid temperate climate now characterized by warm summers and cold winters and by a rainfall of 36 to 40 in. The study of the physical changes of the colloids with advancing development was confined to the amount and distribution of the coarse, medium, and superfine size fractions. The development of horizons I and II is due to the formation and movement of very fine colloidal silicates (the beidellite-type material). The chemical alteration of one mineral to form another does not necessarily involve a change in size of the altered particle. There is the possibility that the product formed by the alteration is more readily broken than the mineral being altered. Physical weathering of the colloid would, in such a case, effect a partial size separation of the altered from the unaltered forms. Subsequent fractionation of the whole colloid would then effect a separation, and the resulting size fractions would vary correspondingly in composition, compared with their composition before physical weathering occurred. The general tendency is for the  $\text{K}_2\text{O}$ ,  $\text{MgO}$ , and  $\text{Fe}_2\text{O}_3$  to decrease with advancing development and the  $\text{SiO}_2$ - $\text{K}_2\text{O}$  ratio to increase, in case of coarse colloids. The  $\text{K}_2\text{O}$  values are greatly reduced in the superfine fractions, while the  $\text{MgO}$  values are only slightly lower. The trend with respect to maturity, however, is the same for  $\text{K}_2\text{O}$ ,  $\text{MgO}$ , and base-exchange capacity as that found in the coarse colloid. Iron, organic matter, and water are decidedly higher in corresponding superfine fractions. In contrast to the coarse colloid, the

$\text{SiO}_2$ - $\text{K}_2\text{O}$  ratios decrease with advancing maturity. Data for the fine colloid are not included but are nearly similar to the superfine values than to the coarse colloid values.

**Clays of Landes.** E. S. GREGORY. *Argile*, No. 105, p. 19 (1956).—The sources of the clays used for the manufacture of brick and tile in the department of Landes, France, are discussed briefly.

**Common orientation and a classification for crystals based upon a mosaic-like packing.** M. J. BURROUGHS. *Amer. Mineralogist*, 22 (1) 48-50 (1957). F.J.Z. *Constitution of zeolite*. L. PASTERNAK. *Gaz. Chim. Ital.*, 65 (6) 534-42 (1935).—Six types of zeolite were investigated: analcime ( $\text{Na}_4\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ ), natrolite ( $\text{Na}_4\text{Al}_2\text{Si}_2\text{O}_{10} \cdot 2\text{H}_2\text{O}$ ), heulandite ( $\text{H}_4\text{CaAl}_2\text{Si}_4\text{O}_{20} \cdot 2\text{H}_2\text{O}$ ), chabasite ( $\text{Ca}_2\text{Na}_2\text{Al}_2\text{Si}_4\text{O}_{20} \cdot 2\text{H}_2\text{O}$ ), and scolecite ( $\text{CaAl}_2\text{Si}_2\text{O}_{10} \cdot 2\text{H}_2\text{O}$ ). The absorption spectra of the crystal water of the first five were found to be the same as for pure water, but for scolecite this was found true only for long wave-lengths.

**Crystal lattice and twin crystals of leucite.** J. WYAT. *Compt. Rend.*, 203 (19) 938-39 (1956).—The diffraction properties of leucite,  $\text{KAlSi}_3\text{O}_8$ , were determined. M.H.

**Dispersion of soil for mechanical analysis by sodium carbonate or sodium acetate treatment.** A. N. PURI. *Soil Sci.*, 42 (4) 267-72 (1956).—The proposed method consists in the estimation of exchangeable Ca and free sodium, sodium carbonate or acetate equivalent to the former and sodium hydroxide equivalent to the latter, being subsequently added; the soil suspension is shaken overnight. To attain maximum dispersion, soils rich in organic matter require boiling with  $\text{H}_2\text{O}$  or ammonium carbonate in addition to the foregoing treatment.

**"Ammonium-carbonate."** *Soil Sci.*, 42 (4) 271 (1956).

**Effect of phosphates on the cation-exchange capacity of certain soils.** A. L. PERDUE AND S. J. TORRE. *Soil Sci.*, 42 (4) 281-90 (1956).—The exchangeable calcium, magnesium, potassium, and sodium showed no significant differences in relation to the amount of added phosphates.

**Essential constituent of the "flint clay" of Normandy.** B. DAKINOV. *Compt. Rend.*, 202 (19) 1505-07 (1956).—The varying character of this flint clay was found to be due to its content of pyrophyllite which in this case is a beidellite without silicon, belonging to the series beidellite-montmorillonite in which  $\text{AlO}_3$  preponderates over  $\text{FeO}_3$ .

**Formation of structure in soil: I. Structure of soil colloids.** D. L. STUART. *Soil Sci.*, 42 (5) 281-93 (1956).—The existence of aggregate phases in soil colloids alters essentially the hydrodynamic behavior. The study of the electric properties of colloidal particles, when they aggregate into groups, are radically changed as a result of the shrinking of the ion envelope. The properties determined by the nature of the adsorbed cations are leveled out in the associated groups. The possibility of spontaneous coagulation, explained by the prevalence of the forces of molecular attraction over those of electrostatic repulsion, is demonstrated. 38 references. II, Synthesis of aggregates. Bonds uniting clay with sand and clay with

humus. *Ibid.*, 42 (6) 461-81.—The former conception that the particles forming the soil structural aggregate are held together by the tension of the water film is supplemented by the finding that the surface film creates a definite orientation of the particles in relation to one another. The tendency of the bond between the separate parts of the soil structural aggregate can not be explained by the tension of absorbed Ca. The explanation of the tendency of the bond lies in the stability of the group arrangement of the particles. The most stable arrangement of particles is the homogeneous one. The formation of nonhomogeneous aggregates in soil sand-clay and clay-humus may be explained by the same laws which have been found to exist for mineral intergrowths. The impossibility of completely separating soil into its elementary parts is corroborated. In connection with the theory developed, it becomes necessary to revise the theory of soil texture. The subdivision of soil into stable and unstable groupings of particles appears to be more expedient. The influence of external conditions (vegetation, microorganisms, tillage, pressure, freezing, etc.) on the formation of structure can be explained by the swarm theory. 40 references. III, Mechanism of the swelling of soil. *Ibid.*, 43 (1) 43-50 (1956).—Water absorption and swelling of soil are determined by the structure of the surface layer of oriented particles. Particular importance is attached, in the case of unstable groupings, to the compactness of the particles at the interface, solid phase-air. Mechanical desiccation of the surface layer leads to disintegration. From the viewpoint of the new conceptions concerning soil structure, it becomes necessary to revise the theory of soil morphology. There is no other field in which the internal relation between the shape of the molecule and the crystal would appear with such clearness as in the mesomorphic state.

**Geochemistry of natural glasses.** A. YA. MIREI. *Trudy Vsesoyuz. Nauchno. Sreda*, 1952, 2 (1) 451-56 (1955); *Chem. Abstr.*, 29, 7582 (1955).—Results of investigations of the Ukrainian Institute of Physical Chemistry of obsidians and pumices in Caucasus are given. Chemical analyses, determinations of specific gravity, and microscopic study of several samples have been made. The causes of the high  $\text{SiO}_2$  of obsidian, as compared with pumice, and of hypogeneis were also investigated.

**Gravitational compaction of clays and shales.** HOLLEN D. HARRIS. *Amer. Jour. Sci.*, 31, 241-87 (1956).—A review of the literature on gravitational compaction shows that special studies have been made of actual data. New data derived from a study of core samples of undisturbed Tertiary strata in Venezuela are presented. The initial porosity of clay and mud ranges from 70% to more than 90% but under a pressure of 400 to 600 lb./sq. in. the porosity is reduced to 35%. The data obtained from the well samples cover the pressure range 50 to 800 lb./sq. in. The rate of decrease in porosity diminishes with increasing pressure. At 800 lb./sq. in. it is still 8 or 9%. Marked changes in the porosity gradient are observed at 800 lb./sq. in. (30 to 35% porosity) and at 600 lb./sq. in. (10%). These are believed to reflect changes in the process of compaction, which is divided into four stages. (A) The initial volume of a fine-grained sediment is dependent chiefly on the volume of the adsorbed film of



water surrounding the particles and on the force of attraction between particles. This last factor is conditioned largely by the presence or absence of electrical charges due to selective adsorption and it controls the original density and looseness of structure to a large extent. The initial stage of compaction is chiefly a gravitational rearrangement of the mode of packing and the expulsion of most of the free water. These changes result from the collapse of the original unstable structure under the increased pressure. (B) The second stage is a further dewatering and covering of the particles by the presence of a stable mechanical arrangement and the condition in which particles begin to come into actual contact, i.e., until true cohesion sets in. (C) The third stage is the complete removal of adsorbed water at the intergranular contacts with the expulsion of about 20 to 35% porosity. Further reduction in volume occurs only with mechanical deformation such as bending, crushing, or granulation. Recrystallization begins in this stage and the elasticity of the material decreases rapidly. (D) The last stage is the slow molecular and chemical readjustment under the high pressures. It starts at a porosity of about 10%. In order to reduce this porosity the pore spaces must be filled by new crystals appearing on the recrystallization.

**Identification of the clay substance in soil by X-ray investigations.** A. JACOB, U. HOPMANN, and H. LOOPMANN. *Trans. Internat. Congr. Soil Sci., 3rd Congress, Oxford, 1935, 1, 88-89; Chem. Abstr., 29, 7550 (1935).*—The authors review and outline procedures and results obtained in the examination of 11 samples from Europe and 10 samples of tropical soils. The clay minerals montmorillonite and kaolinite were identified in clay suspensions less than 2 $\mu$ , and impurities such as quartz as well as the presence of halloysite was not proved. Some of the tropical soils contained kaolinite without montmorillonite. The latter is relatively resistant to chemical attack and is believed to be the crystalline clay mineral most concerned in base-exchange reactions, as many of the remaining soil samples contained little or no kaolinite. Quantitative studies indicated that in some cases an important part of the exchange capacity was in a fraction greater than 2 $\mu$ .

**Index of texture and classification of Philippine soils.** M. M. ALICANTY and D. Z. ROSS. *Philippine Jour. Sci., 59 (4) 605-11 (1935).* R.F.R.

**Interpretation of schistosity.** F. J. TURNER. *Trans. Roy. Soc. New Zealand, 66, 201-241 (1935).*—Schistosity, cleavage, foliation, metamorphism, and their various definitions are discussed from the different points of view of American, British, and European geologists. A bibliography of schistosity is included.

**Method of controlling working properties of clays and kaolins by aromatic and pyrometaphosphate greases.** M. P. YUKNAT. *Keram. St. Stal., 12 (11) 18-23 (1935).*—Details of procedure and directions for testing the liquefaction properties of clay and kaolin are given, and results are tabulated.

**Method for determining porosity of the soil.** G. TUNSTROM and SIGURD ERIKSSON. *Soil Sci., 42 (6) 405-17 (1935).*—A description is given of a new method for the direct measurement of air space in soils based on Boyle's law. The apparatus (the porometer) also permits calcu-

lation, in a simple way, of the specific gravity, water content, and soil substance. G.R.S.

**Milling and classification of feldspars.** V. V. KERNY. *Glass Ind., 17 (10) 333-35 (1936).*—There are six classifications of feldspar which are modified as to particle size and by a great variety of chemical compositions. The need for further simplification of specifications is made clear.

**Notes on Missouri halloysite.** FRANK J. ZYANITE. *Jour. Amer. Ceram. Soc., 20 (1) 84-87 (1937).*

**Podsols and brown forest soils.** I. KARL LUNDHOLM. *Soil Sci., 37 (2) 137-55 (1936).*—The acid-oxide method of Tamun (*Ceram. Abstr.*, 14 (7) 172 (1935)) is presented and discussed together with experiments made to illustrate its applicability. The method gives a measure of the weathering and is useful in characterizing different soil types. 22 references. For Part II see *ibid.*, 16 (1) 40 (1937). G.R.S.

**Properties of clay fractions.** C. E. MARSHALL. *Trans. Internat. Congr. Soil Sci., 3rd Congress, Oxford, 1935, 1, 88-90; Chem. Abstr., 29, 7550 (1935).*—A brief review and critical discussion are given. It is pointed out that increase in exchange capacity does not keep pace with increase in surface as particle size decreases, an indication that exchangeable cations are largely held inside the clay lattice, and there is evidence that such cations occupy definite positions. The clays should therefore be considered aluminosilicates rather than colloidal mixtures of hydrated oxides. It is not possible to predict a close relation between chemical composition and colloidal properties, for the latter are largely dependent upon surface factors in contact with  $H_2O$ . The crystal lattice theory is well suited to base-exchange studies, in spite of failures so far to formulate a satisfactory base-exchange equation.

**Properties of the hydroxyl groups of clay as a basis for characterizing a mineral soil.** WALTER THOMAS. *Soil Sci., 42 (4) 243-59 (1936).*—By treating a soil with increasing amounts of solutions of HCl and of  $NaOH$ , in low concentrations, differences in specific properties of the three types of hydroxyl groups of clays may be used as a means for the rapid characterization of a soil with respect to the degree of unsaturation, total replaceable bases, "free" aluminum and iron hydroxides, phosphoric acid required to satisfy the Al and Fe, lime requirement, availability of the different states of the replaceable potassium, and changes produced by cultivation and fertilizer treatment. 22 references. G.R.S.

**Research on natural raw materials for ceramics in Italy. Clay for the manufacture of stoneware.** P. POZZI. *Corriere Ceram., 17 (11) 316-21 (1935).*—P. shows that any clay which does not contain carbonates can be used for the manufacture of stoneware if, with the necessary corrections in the quartz and feldspar contents, it is made to conform to the limits of the molecular formula given:  $10.00 \pm 0.00 SiO_2 \cdot 2.00 \pm 0.5 Al_2O_3 \cdot 1.00 K_2O = CaO + MgO + FeO + K_2O + Na_2O$ . The chief condition is that the clay should not react in a test with a few drops of HCl.

**Soil swelling: I. Swelling of soil in water considered in connection with the problem of soil structure.** D. I. STEBEL. *Soil Sci., 41 (2) 135-51 (1936).*—The study of the phenomena of the swelling of soil that keeps its natural

structural condition allows investigation of the problem of soil structure from a new point of view. A method is elaborated, and a form is evolved for a quantitative expression of the porosity changes caused by absorption of water by soil. Definitions of the "index of texture stability" (S) and of "swelling water" (W), founded on the sharp difference between capillary imbibition and swelling proper, are introduced. Swelling water may be considered as the form of expressing the hydrophilic property of soil. Soil swelling is considered as a process of changes arising in the properties of soil at the interface, soil colloids/water. This process leads to a change in the structure of soil and to an increase in its degree of dispersion. A quantitative expression of this process is possible in the form of "swelling water" (W), which represents a more characteristic indication of swelling than the increase of volume. A method is proposed for a differential analysis of soil porosity, providing for its subdivision into noncapillary, capillary, and submicroscopic porosity. For Part II see *Ceram. Abstr.*, 16 (1) 41 (1937). G.R.S.

**Spectrographic examinations of colorless and blue halite.** T. G. KENNARD, DAVID H. HOWELL, and M. P. YAROCK. *Amer. Mineralogist, 22 (1) 65-67 (1937).*—No difference in chemical composition was observed between the colorless and blue varieties which have been obtained from the same specimen; the blue color, however, is structural rather than pigmental. F.J.Z.

**Thiocyamate test for soil reaction.** A modified technique and a method of recording results. W. L. RAYMOND. *Jour. Soc. Chem. Ind., 55 (20) 128-29 (1936).*—R. de-

**Active oxides: No. 99. Solubility of a mixture of magnesium oxide and iron oxide in the course of aging.** G. F. HÖTTIG and E. FEIDLER. *Kolloid-Z., 75 (2) 170-84 (1936).*—Portions of an equimolecular mixture of strongly ignited  $MgO$  and  $Fe_2O_3$  were heated to various high temperatures, and the solubilities in HCl, magnetic susceptibilities, and, in a few special cases, the X-ray patterns were determined and compared with check determinations on the pure compounds. Solubilities of pure  $MgO$  and of pure  $Fe_2O_3$  decrease with increasing preheating temperature. The solubilities of both components of the mixture are reduced when aging without activation occurs. Activation of the mixture during heating causes the solubility of the activated component ("active") to increase while that of the inactive ("inactive") decreases. This oxide mixture is compared with mixed catalysts in general, with reference to the relation between the solubility of a system and its free energy. For No. 92 see *Ceram. Abstr.*, 15 (4) 123 (1935). F.J.P.

**Adsorption of aluminum hydroxide by kieselerite.** R. C. C. BAILY and W. P. FERRIS. *Nature, 136 (3427) 28 (1935).*—Aluminum hydroxide is readily adsorbed by kieselerite (diatomaceous earth) to form a remarkably stable adsorption complex. The hydroxide is deposited by the slow addition of a small excess of ammonia to a desired suspension of 10 g. of specially purified Superiores kieselerite in 100 cc. of 2% ammonium nitrate solution containing a known amount of aluminum nitrate. From the amount of aluminum hydroxide adsorbed and from

series a technique for the thiocyamate test for soil acidity, to which greater precision is given by the use of a computer, for whereby numerical values can be assigned to the red colors developed. G.R.S.

## BOOKS AND BULLETINS

**Economic Geology of Mineral Deposits.** ERNEST L. LILLY. Henry Holt & Co., New York, 1936. x + 811 pp., 301 figs. Price \$5.00. Reviewed in *Exam. Geol.*, 31 (12) 885 (1936).

**Outline of the mineral resources of Virginia.** WILLIAM M. MCGILL. *Virginia Geol. Survey Bull. 87* (Educational Series, No. 8) 811 + 81 pp. (1935).—A summary report on the mineral resources of Va., based upon previous publications and recent field work, is presented. The report contains a concise discussion of the most important mineral resources in the State, including coal, construction materials, gold, limestone, dolomite and calcareous marls, manganese, other metallic deposits, and nonmetallic resources. The main features of each kind of mineral deposit are briefly described. The distribution of the chief mineral resources is given on a series of seven maps which show coal-bearing areas, distribution of construction materials, gold districts, and distribution of calcareous deposits, manganese deposits, metallic deposits, and nonmetallic resources. The discussion of nonmetallic resources includes data on barite, clay, diatomite, emery, feldspar, gypsum, kaolin, kyanite, mica, ortho, sil, talc, soapstone, and talc. A.C. BAYAN

## Chemistry and Physics

**The reacting electrokinetic potential (zeta) of the particles, as shown by their movement in an electric field in  $N/30$  acetic acid, it is concluded that aluminum hydroxide is adsorbed first as a unimolecular layer with a zeta value of 75.4 mv. This layer then heavy adsorb a second unimolecular layer with a drop of zeta to 61.2 mv. The layer has the same properties as the unadsorbed substance. The changed electrokinetic potential for surfaces containing the same number of molecules indicates that the molecules in the first adsorbed unimolecular layer must be activated in some manner. Further addition of aluminum hydroxide to the second layer does not change the zeta value of 61.2 mv, which is that of free unadsorbed aluminum hydroxide in  $N/30$  acetic acid. See *Ceram. Abstr.*, 15 (4) 285 (1935).**

**Analytical chemistry of tantalum, niobium, and their mineral associates.** Observations on phosphorus, vanadium, and a tannin precipitation series. W. R. SCHMIDT and H. W. WARD. *Analyst, 61 (720) 855-80 (1936).*—Phosphoric acid is occluded in the earth-alkali precipitate produced by tartaric hydrolysis; it may be determined in the precipitate by fusion with  $NaOH$ , which produces soluble Na phosphate but insoluble tantalate and niobate. Vanadium may be separated from Ta and Nb ( $Ca$ ), as it is not occluded in the tartaric precipitate but is quantitatively precipitated by tannin. A tannin precipitation series is Ta, Ti, Nb, V, Fe<sup>3+</sup>, Zr, Hf, Th, U, and Al, the first being precipitated at the greatest acidity. See *Ceram. Abstr.*, 15 (4) 313 (1935). H.J.S.

**Application of the theory of thermal oscillation to the field of mesophases (liquid crystals).** H. ZOOZ. *Kolloid-Z., 75 (2) 161-63 (1935).*—Failure of the Orstein and the Bose applications of the swarm theory to explain phenomena on thin and on thick nematic layers is discussed. It is shown that the theory of thermal oscillations satisfactorily explains Maugué's sparkling phenomena, clouding of similarly oriented fields, and temperature variations of the various classes of anisotropy. F.P.P.

**Application of viscometry and plastometry to problems of applied mineralogy.** M. P. VOLAROVICH. *Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Mineral. St. Stal., No. 66, 95 pp. (1934); Chem. Abstr., 29, 4992 (1935).*—Reviews the general concept of viscosity and plasticity, the methods used for measuring plasticity of mineral suspensions, and the application of such methods at high temperatures; references are appended. The apparatus of Volarovich for measuring plasticity of clay and similar suspensions (Volarovich and Tolstol, *Ceram. Abstr.*, 13 (10) 278 (1934)) is described, and the results of such measurements are compared with those obtained by the apparatus of Tolstol (*Zhur. Fiz. Khim.*, 5, 28 (1934)). For measuring viscosities at high temperatures the proposed apparatus consists also of two coaxial cylinders made from a Pt-Ir alloy, but the rotating cylinder is the outer one. The apparatus is improved in an electric oven of special design. Results obtained with  $SiO_2-Al_2O_3-CaO$  slags are in general agreement with the results of other investigators. Viscosity of slags containing 28 to 36%  $TiO_2$  is tabulated. The addition of NaCl to such slags has little effect in lowering viscosity. The effect of  $Na_2O$  is also small and sometimes in the opposite direction. It is of interest that the decrease in acidity of such slags, as determined by the  $(TiO_2 + SO_3)/CaO + MgO$  ratio, is accompanied by increase in viscosity at the melting point. In general, the work with  $TiO_2$  slags is complicated by their instability. Work with glasses and coal tars indicates that they behave like Newtonian liquids and do not exhibit plastic properties in the liquid state. Certain metal particles containing  $TiO_2$  are plastics. This is explained by the colloidal nature of such slags. Work with emulsions used for manufacturing kitchenware shows that the addition of  $Na_2CO_3$  increases their viscosity-temperature gradient considerably. Results on measuring viscosities of minerals used in glass manufacture (basalt, tephinite, and obsidian, diatomite, etc.) are also given. Their viscosity-temperature gradient is considerably greater than that of glass. Comparison of the viscosity of minerals with their composition indicates that basic substances decrease their viscosity in the molten state while acidic substances have a reverse effect. The plastic properties appear when certain components of such systems begin to crystallize, which is particularly noticeable with minerals of low viscosity at high temperatures. Such measurements are helpful for determining the suitability of various minerals for manufacturing glass. They also explain certain geological phenomena in the neighborhood of volcanoes.

**Bibliography of ceramic micrographs.** T. N. MCVEY. *Bull. Amer. Ceram. Soc., 16 (2) 31-61 (1937).*

**Chemical and X-ray investigations on the mineral sorption substance in soils.** A. JACOB, U. HOPMANN, H. LOOPMANN, and R. MARGREFAU. *Beih. Z. Ver. Deut.*

*Chem.*, No. 21; *Angew. Chem.*, 48, 685-86 (1935); *Chem. Abstr.*, 29, 8197 (1935).—The following properties of soils were determined: ratio of sesquioxides to  $SiO_2$ , ratio of  $Al_2O_3$  to  $SiO_2$ , S and T values, behavior on treating with concentrated HCl, and X-ray patterns. The results indicated that mixed gels are not the mode of exchange adsorption in soils. It is to be concluded that the base exchange in soils is effected by the crystalline minerals kaolinite and montmorillonite and a clay mineral,  $\alpha$ , which needs further investigation. The clay minerals probably were not formed from amorphous substances, but represent a very stable decomposition product of soil-forming materials.

**Clay and the colloidal state.** MARCEL ANKAY. *Agriculture, 16, 197-205 (1935); Chem. Abstr., 29, 7751 (1935).*—A. discusses colloidal solutions, particularly of clay colloids, their electrolytic properties, stability of the micelles, effect of electrolytes, and preparation of the solutions. An electrophoresis apparatus is described.

**Crystalline boron.** D. P. MALLOR, S. B. COHEN, and E. B. UNDERWOOD. *Jour. Australian Chem. Inst., 3, 329-33 (1935).*—Dark silver-gray crystals of B were obtained by reducing  $BH_3$  with dry hydrogen. Their density is 2.26 and their hardness the same as that of silicon carbide. H.H.S.

**Current-conducting properties of slags in electric furnaces.** L. A. WERNIK. *Trudy Elektrotekhn. Soc., 65, 319-26 (1934); Zh. Fiz. Khim. Abstr., 33 (26) 633 (1934).*—Silicates of the series  $B_2O_3-SiO_2$ ,  $Al_2O_3-SiO_2$ , and  $CaO-SiO_2$ , where R is Fe or Ca in various proportions, were prepared by fusion of the pure oxides under  $N_2$  in an electrically heated crucible of pure Fe. Their electrical conductivity,  $k$ , was measured at 1344 to 900°, using alternating current, with the crucible as one electrode and an adjustable vertical electrode just dipping into the silicate melt. With fall in temperature,  $k$  decreases regularly to the freezing point, where there is a sharp drop. Silicates rich in Fe have higher conductivities, and retain an appreciable volume of  $k$  even in the solid state; an increasing proportion of Ca lowers  $k$  progressively. The variation of  $k$  with temperature for the various compositions and the freezing point are shown graphically; composition curves are recorded for the three series of silicates.

**Determination of iron in sands by the spectrographic method.** PIERRE GILARD, LÉON DUBREIL, and FRANÇOIS JAMAR. *Verre et Silicates Ind., 7 (35) 414-17 (1935).*—An arc was formed between two electrodes of electrolytic copper (separated by 3 mm.), intensity 4 amp., fed by continuous current 120 v. with resistance, 0.01 mm.; duration of exposure 30 or 60 sec. with logarithmic discontinuous circuit. The sand is placed on the cathode. The method gives sufficient precision above 0.05%  $Fe_2O_3$ ; under this concentration it should give good results but requires a complementary test with electrodes which are spectrographically pure. In analyses in 10 min. per sand may be counted on. Tables of the determination are given. M.V.C.

**Determination of lead in potable waters.** S. L. TOMPKINS. *Analyst, 61 (726) 291-97 (1936).*—The presence of Pb in normal human dietaries has been established. Pb in water may be estimated colorimetrically by diphenylthiocarbamate. If Fe content is high, a preliminary separation of Pb is necessary, a suitable reagent being Na di-

ethyldithiocarbamate. H.H.S.

**Determination of small amounts of platinum in minerals, alloys, scrap material, etc.** Separation and concentration of platinum by coprecipitation with tellurium. S. KUNEN. *HANSEN. Mikrochem.*, 20, 182-88 (1935).—Platinum may be reduced from an acid solution (HCl) of sodium tellurate with sulfuric acid under such conditions that only the platinum metals (gold, selenium, molybdenum, and mercury) will be precipitated. Other metals are either not precipitated at all or only in very small amounts. This fact makes it possible to separate and determine very small admixtures of platinum (less than 0.0001%). A series of tests is described. L.E.T.

**Exact determination of silica in sands and aluminous silicates.** ANNIE SYMON. *Jour. Chem., 19, 29-42, 57-63 (1935); Chem. Abstr., 29, 7867 (1935).*—Reviews opinions as to the need of 1, 2, or 3 evaporations to render the silica completely insoluble and as to the different temperatures of heating the residue. A mixture of Na and K carbonates in equimolecular proportions was used as a flux to reduce fusing temperature to 490°. S. discusses the various acids of silica that may be formed during analysis. The method of analysis used was that given in "Cours d'analyse quantitative des Produits Chimiques" by Maurice, with slight changes. A porcelain evaporating dish is used instead of a glass flask when dissolving the fume sample and only a little water is used. Results of tests are tabulated to show the effect of duration of the drying period at temperatures varying from 120 to 150°. The analyses show that a single evaporation does not render the silica completely insoluble. In one series of tests the residue was treated with concentrated HCl and then heated several minutes in a boiling water bath. The quantity of silica appearing in the second evaporation was greater than when the cold acid was used. The tables showing the effect of the presence of Al and Fe salts indicate a slight entrainment of Al. Tables indicating a similar effect when Ca and Mg are present are given. Two silica-aluminous earths containing 40 and 20% alumina, respectively, were tested and the results are given. In all cases two evaporations were found necessary. S. recommends a drying period of 2½ hr. at a temperature of 120°.

**Extraction of aluminum oxide from clay with ammonium sulfate.** Carbon-containing shale of Khakassia as a raw material for alumina. A. P. PRISTOVY, V. P. NIKOLAYEV, and V. A. ANANASOVA. *Zap. Malys. No. 7-8, pp. 27-31 (1932); No. 1, pp. 14-16 (1933); Chem. Zentr., 1933, 1, 2611; 14, 1412; Brit. Chem. Abstr., 54 (1) 20 (1935).*—Kaolin ( $Al_2O_3$  33.13,  $Fe_2O_3$  0.6%) was stirred for 28 min. with  $(NH_4)_2SO_4$  at 40° and extracted for 2 hr. with  $H_2O$  (100% yield of Al as  $(NH_4)_2SO_4$ ,  $Al_2O_3$  241.0%). The ash from the shale oil (32 to 40%  $Al_2O_3$ ) was extracted with  $(NH_4)_2SO_4$  as above, 70 to 80% of the  $Al_2O_3$  being rendered soluble.

**General rule of composition in polymorphism.** M. J. BURKARD. *Proc. Nat. Acad. Sci., 22 (1) 685-89 (1935).*—Degree of composition in a crystal given line is brought about by solid solution. The simple types of solid solution are (1) adatom or interstitial solid solution, (2) proxy solution, and (3) omission solution. B. considers the altera-

tions imposed by these conditions on the cluster vibration theory of polymorphism. In general, if an impurity is to be housed, the modification best adapted to housing it is the form. B. recommends that Barth's definition of polymorphism be amended by dropping the constant chemical composition stipulation to read "Polymorphism includes any possible difference encountered in the crystal structure of a substance, excepting homogeneous deformations." J.L.G.

**Hydroxyquinoline process for rapid determination of alumina.** W. STROM. *Ber. Deut. Chem. Ges., 16 (11) 624-27 (1935).*—A comparison was made of hydroxyquinoline of alumina by the use of hydroxyquinoline, ammonia, and ammonium phosphate. When hydroxyquinoline is used, the accuracy is as great and there is a saving in chemicals used, gas burned, and time required for the analysis. R.V.P.

**Interrelations of compressibility, melting point, solubility, and other properties of the halides of alkali and alkaline earths.** SOFONIA BALCE. *Philosophie Jour. Sci., 60 (5) 251-54 (1935).* R.P.F.

**Investigation into the oxidizing power of basic slag I. Determination of the binary diagram  $CaO-Fe_2O_3$ .** II. Determination of the dissociation pressures of  $Fe_2O_3$ ,  $CaO-Fe_2O_3$ , and  $2CaO-Fe_2O_3$ . J. WARRS, R. GARDNER, and R. HAY. *Jour. Iron & Steel Inst. (London), 11, 91-113 (1935).*—The pseudobinary system  $Fe_2O_3-CaO$  (pseudobinary because of the dissociation of  $Fe_2O_3$  at high temperatures) contains two compounds,  $CaO-Fe_2O_3$  and  $2CaO-Fe_2O_3$ . The properties of the phases present are as follows:  $Fe_2O_3$ , refractive index greater than 2.95, less than 3.10; deep red; slightly pleochroic; straight extinction; uniaxial; negative; apparent melting point 1595°C but this figure is believed to be low owing to dissociation.  $CaO-Fe_2O_3$ , refractive index between 2.5 and 2.6; reddish brown; breaks in thin sections; pleochroic; high polarization colors; straight extinction; uniaxial; melt made up of dark needles having a metallic luster, which, though very hard, could be scratched with a knife. The compound melts inconspicuously at approximately 1220°C and is completely liquid at 1240°C.  $2CaO-Fe_2O_3$ , refractive index between 2.3 and 2.36; light brown; decidedly pleochroic; nearly straight extinction; biaxial; melt tabular in appearance and not so hard as the monoclinic ferrite; melts inconspicuously at approximately 1440°C and is completely liquid at 1450°C. There is a eutectic at 90 wt. %  $Fe_2O_3$  and approximately 1205°C. The dissociation pressure of  $Fe_2O_3$  is appreciable at 1100°C, increases rapidly with temperature, and is of the order of  $5 \times 10^{-10}$  atmospheres at its melting point.  $Fe_2O_3$  is partially soluble in  $Fe_2O_3$ , the solubility ranging from about 10 wt. % at 1100°C to 30% at 1400°C.  $Fe_2O_3$  is also soluble in  $Fe_2O_3$ , the solubility increasing from 10 wt. % at 1100°C to about 20% at 1400°C. A partial diagram for the system  $Fe_2O_3-CaO$  is given. The dissociation of  $CaO-Fe_2O_3$  and  $2CaO-Fe_2O_3$  was investigated. Below the peritectic temperatures the oxygen pressure is infinitesimal, at high temperatures the pressure is due to dissociation of  $Fe_2O_3$  resulting from the peritectic reactions. The oxygen pressure of the ferrites falls rapidly as  $FeO$  increases.  $CaO$  has a marked stabilizing effect on  $FeO$ . J.B.A.

**Kinetic basis of crystal polymorphism.** M. J. BURKARD.







preliminary work presents "the methods and instruments used in conducting dust studies in industry, the interpretation of results thus obtained, and their practical application to industrial problems, especially those phases relating to control of the dust hazard." Preliminary procedure involves the sanitary and occupational survey of a plant; final emphasis is placed on personal respiratory protection of workers. Between these occurs the dust technique.

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centimeter, a (1) (3) 6, Reaction time, 10 min, and CaO/Al<sub>2</sub>O<sub>3</sub> 1.0, 1.2, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 12.0, 15.0, 20.0, 25.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0, 120.0, 150.0, 200.0, 250.0, 300.0, 400.0, 500.0, 600.0, 700.0, 800.0, 900.0, 1000.0, 1200.0, 1500.0, 2000.0, 2500.0, 3000.0, 4000.0, 5000.0, 6000.0, 7000.0, 8000.0, 9000.0, 10000.0, 12000.0, 15000.0, 20000.0, 25000.0, 30000.0, 40000.0, 50000.0, 60000.0, 70000.0, 80000.0, 90000.0, 100000.0, 120000.0, 150000.0, 200000.0, 250000.0, 300000.0, 400000.0, 500000.0, 600000.0, 700000.0, 800000.0, 900000.0, 1000000.0, 1200000.0, 1500000.0, 2000000.0, 2500000.0, 3000000.0, 4000000.0, 5000000.0, 6000000.0, 7000000.0, 8000000.0, 9000000.0, 10000000.0, 12000000.0, 15000000.0, 20000000.0, 25000000.0, 30000000.0, 40000000.0, 50000000.0, 60000000.0, 70000000.0, 80000000.0, 90000000.0, 100000000.0, 120000000.0, 150000000.0, 200000000.0, 250000000.0, 300000000.0, 400000000.0, 500000000.0, 600000000.0, 700000000.0, 800000000.0, 900000000.0, 1000000000.0, 1200000000.0, 1500000000.0, 2000000000.0, 2500000000.0, 3000000000.0, 4000000000.0, 5000000000.0, 6000000000.0, 7000000000.0, 8000000000.0, 9000000000.0, 10000000000.0, 12000000000.0, 15000000000.0, 20000000000.0, 25000000000.0, 30000000000.0, 40000000000.0, 50000000000.0, 60000000000.0, 70000000000.0, 80000000000.0, 90000000000.0, 100000000000.0, 120000000000.0, 150000000000.0, 200000000000.0, 250000000000.0, 300000000000.0, 400000000000.0, 500000000000.0, 600000000000.0, 700000000000.0, 800000000000.0, 900000000000.0, 1000000000000.0, 1200000000000.0, 1500000000000.0, 2000000000000.0, 2500000000000.0, 3000000000000.0, 4000000000000.0, 5000000000000.0, 6000000000000.0, 7000000000000.0, 8000000000000.0, 9000000000000.0, 10000000000000.0, 12000000000000.0, 15000000000000.0, 20000000000000.0, 25000000000000.0, 30000000000000.0, 40000000000000.0, 50000000000000.0, 60000000000000.0, 70000000000000.0, 80000000000000.0, 90000000000000.0, 100000000000000.0, 120000000000000.0, 150000000000000.0, 200000000000000.0, 250000000000000.0, 300000000000000.0, 400000000000000.0, 500000000000000.0, 600000000000000.0, 700000000000000.0, 800000000000000.0, 900000000000000.0, 1000000000000000.0, 1200000000000000.0, 1500000000000000.0, 2000000000000000.0, 2500000000000000.0, 3000000000000000.0, 4000000000000000.0, 5000000000000000.0, 6000000000000000.0, 7000000000000000.0, 8000000000000000.0, 9000000000000000.0, 10000000000000000.0, 12000000000000000.0, 15000000000000000.0, 20000000000000000.0, 25000000000000000.0, 30000000000000000.0, 40000000000000000.0, 50000000000000000.0, 60000000000000000.0, 70000000000000000.0, 80000000000000000.0, 90000000000000000.0, 100000000000000000.0, 120000000000000000.0, 150000000000000000.0, 200000000000000000.0, 250000000000000000.0, 300000000000000000.0, 400000000000000000.0, 500000000000000000.0, 600000000000000000.0, 700000000000000000.0, 800000000000000000.0, 900000000000000000.0, 1000000000000000000.0, 1200000000000000000.0, 1500000000000000000.0, 2000000000000000000.0, 2500000000000000000.0, 3000000000000000000.0, 4000000000000000000.0, 5000000000000000000.0, 6000000000000000000.0, 7000000000000000000.0, 8000000000000000000.0, 9000000000000000000.0, 10000000000000000000.0, 12000000000000000000.0, 15000000000000000000.0, 20000000000000000000.0, 25000000000000000000.0, 30000000000000000000.0, 40000000000000000000.0, 50000000000000000000.0, 60000000000000000000.0, 70000000000000000000.0, 80000000000000000000.0, 90000000000000000000.0, 100000000000000000000.0, 120000000000000000000.0, 150000000000000000000.0, 200000000000000000000.0, 250000000000000000000.0, 300000000000000000000.0, 400000000000000000000.0, 500000000000000000000.0, 600000000000000000000.0, 700000000000000000000.0, 800000000000000000000.0, 900000000000000000000.0, 1000000000000000000000.0, 1200000000000000000000.0, 1500000000000000000000.0, 2000000000000000000000.0, 2500000000000000000000.0, 3000000000000000000000.0, 4000000000000000000000.0, 5000000000000000000000.0, 6000000000000000000000.0, 7000000000000000000000.0, 8000000000000

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## Research (continued) 1021      Realists (continued) 1021

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